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Introduction

Physics is the most fundamental science and underlies our understanding of nearly all areas of science and technology. In a broad sense, physics is concerned with the study of energy, space, matter, and the interactions between them. Specific areas of study that physicists pursue include atomic physics, nuclear physics, biophysics, condensed matter physics, electricity and magnetism, particle physics, optics, thermodynamics, gravitation, relativity, and mechanics.

Astronomy, the search to understand our place in the Universe, motivated the development of modern science. Recent advances in observational technology and space exploration have greatly extended the reach of planetary science, astrophysics, and cosmology, resulting in important fundamental discoveries in these areas. Using the physics toolbox, astronomers probe the origin of the elements, the formation and nature of stars and galaxies, and the 95% of the Universe made up of dark matter and dark energy.

Students who graduate from our programs have the opportunity to experience several tracks of study. Common to these tracks is a solid background in the fundamental laws of physics as well as a strong component of practical skills that are beneficial in a wide range of careers.

All of our full-time faculty members hold PhD degrees in physics, astronomy, or a closely related field. Each of our part-time faculty members also hold an advanced degrees (Masters or PhD). Graduates regularly praise the effectiveness, dedication, and availability of our faculty in our alumni and exit interviews. Our faculty has a long tradition of excellence, winning several Outstanding Teaching, Scholarly Activity, and Service Awards over the years.

Our program is very robust. Aside from a small dip during COVID, we have been graduating nearly 20 students a year for the last decade. While that might seem small, it is actually one of the largest bachelors-only programs in the country. We have also hired eight new faculty members since 2014 and hope to hire more in the coming few years. About half of our graduates have continued their studies in graduate programs; including alumni who have continued their studies at U.C. Berkeley and other University of California campuses, Harvard, MIT, Princeton, Nebraska, Northern Arizona, University of Alaska, Oregon, and others. Our graduates who go on to earn their teaching credentials are being hired immediately by regional high schools – usually being offered jobs before their credential is even finalized! Those that go into industry find themselves successful careers in a wide range of places. Some employers you may know are: Intel, Pixar, Google, Lawrence Livermore National Laboratory, Facebook, Apple, the United States Air Force, and the State of California's Radiological Health Branch.

Academic Programs

Majors

Bachelor of Science in Physics – The Bachelor of Science (BS) in physics is geared for those who wish to pursue further studies in physics and/or astrophysics. It is a rigorous, broad, and versatile degree.

Bachelor of Science in Physics, Applied Physics Concentration – This concentration within our BS degree prepares graduates for productive careers in industry with a strong physics core coupled with practical skills and elective flexibility. Those interested in advanced study in related fields (Material Science, Engineering, etc.) may find value in this program.

Bachelor of Science in Physics, Biophysics Concentration – This concentration within the BS degree provides a strong background in both physics and biology relevant both for future graduate study, or working in the field of biotechnology.

Bachelor of Arts in Physics – The Bachelor of Arts (BA) in physics is designed to be a flexible, liberal arts degree for those planning on careers in industry, government, or other fields.

Bachelor of Arts in Physics, Teacher Preparation Concentration – This concentration in our BA degree prepares graduates for a career in teaching with additional coursework and classroom experience to help launch a career in education.

Certificates/Minors

Certificate Program in Scientific Instrument Development – Students earning this certificate will be prepared to design, prototype, and construct instruments for a wide range of scientific applications. Open to all majors.

Certificate Program in Scientific Computing and Simulation – Students earning this certificate will acquire a good grounding in computer-based skills of formulating and solving science and engineering problems. This program will better prepare students for today's industrial and academic careers. Open to all majors.

Minor in Astronomy – A secondary field of study open to all majors, including Physics. With this minor, you'll learn about our universe, galaxies, and the solar system. This minor is also good preparation for graduate studies in astrophysics.

Minor in Physics – A secondary field of study taken most often by Chemistry and Engineering majors, it is not available to Physics majors. Tell your friends....

Faculty and Staff

Full-time Faculty Name	Ph.D. Institution	Research Interests	Email @csus.edu
Rodolfo Barniol Duran Assoc. Professor	University of Texas	Theoretical High Energy Astrophysics	BarniolDuran
Matt Block Professor	University of California, Santa Barbara	Theoretical condensed matter, computational methods	Matthew.Block
Jérôme Bürki Professor	University of Fribourg	Nanophysics, theoretical condensed matter, computational tools	Buerki
William DeGraffenreid Professor	University of Maryland	Laser spectroscopy, atomic physics, instrumentation, scientific professionalism	DeGraff
Mikkel Jensen Assoc. Professor	Boston University	Biophysics, soft condensed matter	Mikkel.Jensen
Vera Margoniner Professor	National Observatory of Brazil	Astronomy, physics and science education	Vera.Margoniner
Eliza Morris Assoc. Professor	Harvard University	Biophysics, Environmental Physics	Eliza.Morris
Joshua Moss Professor	College of William and Mary	High energy physics	Joshua.Moss
Alexander Pettitt Asst. Professor	University of Exeter	Structure and Evolution of Galaxies	Pettitt
Michael Ray Assoc. Professor and Department Chair	University of Massachusetts, Amherst	Low temperature physics, quantum solids, instrumentation	Ray
Brianna Santangelo Asst. Professor	North Dakota State University	Physics Education Research	Brianna.Santangelo
Tatiana Sergan Professor	Institute of Physics, Ukrainian Academy of Sciences	Liquid crystalline materials and applications, ordered layers, holography	TSergan
Vassili Sergan Professor	Institute of Physics, Ukrainian Academy of Sciences	Physics of anisotropic fluids, electo- optical devices	VSergan

Full-time Faculty Name	e Faculty Ph.D. Institution Research Interests		Email @csus.edu		
Lynn Tashiro Professor Director, Center for Teaching and Learning	Stanford University	Science education	TashiroL		
Christopher Taylor Professor, and Interim Associate Dean, NSM	University of Minnesota	Radio astronomy, galaxy evolution, dwarf galaxies	CTaylor		

Staff Name	Title	Email @csus.edu
Andrew Lozano	Instructional Support Technician II / Stockroom Supervisor	A.Lozano
Heidi Yamazaki	Department Office Manager / Administrative Support Coordinator	Yamazaki
Claire Shudde	Planetarium Events Coordinator (Administrative Support Coordinator, Geology)	Shudde

Student Life

Society of Physics Students

The Department of Physics and Astronomy has an award-winning chapter of the Society of Physics Students (SPS). The National SPS Office is part of the American Institute of Physics. SPS members volunteer in the Physics Tutoring Center, go on field trips, have social events, and perhaps most importantly, bring coffee and cookies to our colloquia. The Department pays the membership of all majors in the national organization. Local due-paying members of SPS have access to Sequoia 140, the Electronics and Instrumentation Laboratory, as a place to hang out between classes and study in groups.

Women and Intersectionality in Physics and Astronomy

The Department's official student organization to support women and other historically underrepresented groups who are Physics majors as they start their careers in science. WiPA holds both informal chats and organizes attendance at professional development workshops, as well as being a vital part of the Department's public outreach efforts. In recognition of this work, WiPA received a grant from the American Physical Society.

Astronomy Club

The Astronomy Club is a student organization on campus open to any student interested in astronomy. The club holds biweekly meetings and organizes astronomy events. The club has recently organized planetarium shows and telescope use training for its members. The club has also held stargazing opportunities and solar observing for the general public. All are welcome to join the astronomy club.

Advising

Each of our majors is assigned to an academic advisor and is required to meet with them prior to registering each semester. This ensures that the students are making good decisions in their class choices and are satisfactorily progressing toward their degree. It also reinforces the "family" atmosphere that we value and promote. Advisors can provide information about summer internships, graduate programs, and career opportunities.

Physics Colloquium Series

The Physics Colloquium Series is one of the longest running programs at Sacramento State. We host approximately ten speakers from around the country and the department each semester. Through this series, students are exposed to timely topics in physics and astronomy, history of physics, career opportunities, and the research activities of fellow students and professors. All physics majors are required to attend at least twenty talks before graduation. Colloquia are Thursdays at 4:00 – 5:20.

Research

Many of our majors are involved in research during their studies. Students earning the traditional BS in Physics are required to do a Senior Project as part of their degree and it is an option for those in the Applied Physics Concentration and Biophysics concentrations. The Senior Project can also be used to satisfy the upper-division elective requirements in the BA degrees. Some students will use a summer internship at a national laboratory or research university to satisfy this requirement, but the majority do their work on campus with a faculty member. Students work closely with faculty members in areas of instrumentation, biophysics, spectroscopy, liquid crystals, low temperature physics, computational physics, physics education research, cosmology, compact stellar remnants, and galaxy evolution.

Tutoring Center / Physics Library

The Department operates the Tutoring Center in Sequoia 238 for students who need help with their studies in lower-division physics. The center is staffed by physics faculty and upper-division physics majors. The tutoring is free. The room also has a broad collection of textbooks at all levels that have been donated to the Society of Physics Students for use by students.

Awards and Scholarships

We are fortunate to be able to offer a number of scholarships to our majors. Most years, we award around \$20,000 in scholarships and awards to Physics majors. While many of these scholarships are only open to juniors and seniors (such as the Vanderberg Scholarship and Senior Award), others are open to "younger" students (Maxwell Awards, Fenton, Iloff) as well. Students must apply for scholarships through Sac State's online application system. Juniors and seniors who have demonstrated high achievement in physics may be eligible to be inducted into our chapter of Sigma Pi Sigma, the National Physics Honor Society. The Summer Undergraduate Research Experience (SURE) program, administered by the College of Natural Sciences and Mathematics, provides summer employment for about a dozen students in the college; Physics and Astronomy majors have been well represented in this program. In addition to the college program, the department has created two additional programs for employing students working on research projects, the Partovi Summer Undergraduate Research Experience (P-SURE) and the Wrightson Summer Undergraduate Research Experience (W-SURE). These programs recognize the long contributions of two late physics faculty members, Dr. Hossein Partovi and Dr. Frances Wrightson. These programs are limited to physics majors.

Employment

We occasionally hire students to work as stockroom assistants, learning assistants in introductory classes, astronomy teaching assistants, and Planetarium field trip hosts. Many of these positions are under the federal work-study program; see the Financial Aid office for more details on applying for work-study positions. Check with the Department Office before the start of the semester to see if any positions are available.

Physics Major Checklist

Use the following table to keep track of your graduation requirements within the Department of Physics and Astronomy based the most recent "Catalog Rights." If you have older rights, please see your advisor for the difference between what is below and what you are entitled to. Please see the University Catalog for details about General Education and University graduation requirements. Remember, you are responsible for knowing the policies of the University.

Course Number			2024 – Present ¹				Notes:
	(Updated 10/24)	BA	BA TPC	BS	BS AP	BS Bio	The officia
	PHYS 11A						published
	PHYS 11B						the most r
	PHYS 11C						
	MATH 30						2. Student
	MATH 31						Physics ar
uo	MATH 32						University
visi	MATH 45						roquiromo
Ē	CHEM 1A / CHEM 1E (AP)						this Univer
ver	CHEM 1B / ENGR 45 (AP)						
2	BIO 1						
	BIO 2						3. Student
	ASTR 4A or 4B or 4C + ASTR 6						Concentra
	GEOL 10 + GEOL 10L						1A or CHE
	ENVS 10						declaration
	CSC 25						allowed to
	PHYS 105						CHEM 1E
	PHYS 106						•••••
	PHYS 110						1 Eligible
	PHYS 115	Pick		Pick			4. Eligible
	PHYS 145	One		One		1	upper-aivis
	PHYS 124						specifically
c	PHYS 135						program ir
sio	PHYS 136						for the BA
) İ	PHYS 150						departmer
- L	PHYS 151						adviser an Classes in General Ed major. 5. The Cor has not be
Uppe	PHYS 156	Î					
	PHYS 162						
	PHYS 172						
	PHYS 175						
	PHYS 191 (or 116/163 for						
	AP/Bio)						
	PHYS 199 (1 unit min)						
	UD Elective Units	8	6	3	9	1-4	few years.
Seminar Attendance		N	lust att	end at	: least	20	requireme
		seminars				taken at a	

 This is a guide to help students.
The official requirements are bublished in the University Catalog for he most recent info available.

2. Students earning a BS degree in Physics are exempted from the University Foreign Language requirement. Both BA programs retain this University graduation requirement.

3. Students in the Applied Physics Concentration that completed CHEM 1A or CHEM 1B <u>prior to</u> declaration/change of major will be allowed to use these courses in lieu of CHEM 1E and ENGR 45, respectively.

4. Eligible courses include a variety of upper-division courses in Physics not specifically required by your degree program in the above table (i.e. 150 for the BA), and others in other departments with the approval of your adviser and Department Chair. Classes in the PHYS 180s are General Ed and not appropriate for the major.

5. The Computer Science department has not been offering CSC 25 for a few years. We will generally waive this requirement if a similar class isn't taken at a community college.

Sample Four-Year Physics Schedules – Roadmaps

Please see the current University Catalog (catalog.csus.edu) for "roadmaps" for freshman and transfer students. Below is a sample for the BS for 4-years (e.g. Freshman). For each degree, there are both 4-year and 2-year roadmaps available to consult. These roadmaps all make some assumptions about what your preparation is upon starting at Sac State. These samples may not match your exact path as you may be either a bit ahead or a bit lagging compared to these assumptions. You generally may also take lower division GE courses in any order.

Physics, BS: 4-Year Roadmap

Year 1		
FIRST SEMES	TER	UNITS
<u>MATH 30</u>	Calculus I	4
GE Area 10	2 - Oral Communication ²	3
GE Area 3A	A - Arts ²	3
GR Americ	an Institutions (GOVT) ²	3
Elective of	Choice	3
	Units	16
SECOND SEM	ESTER	
<u>MATH 31</u>	Calculus II	4
<u>PHYS 11A</u>	General Physics: Mechanics	4
GE Area 1A	A - English Composition ²	3
GE Area 5E	3 - Biological Science ²	3
	Units	14
Year 2		
FIRST SEMES	TER Coloulus III	1
MATH AF	Calculus III Differential Enverting for Crience and Environment	4
$\frac{MAI \Pi 45}{DUVC 44C}$	Differential Equations for Science and Engineering	3
<u>PHYS I IC</u>	General Physics: Electricity and Magnetism	4
GE Area 1E	3 - Critical Thinking ²	3
GE Area 3E	3 - Humanities ²	3
CECOND CEM	Units	17
ENGL 20	College Composition II	3
PHVS 11R	Conoral Physics: Hoat Light Sound Modern Physics	3
CE Aron 4	Social & Pohavioral Sciences	4
GE Area C		
GE Area 6		3
GR Americ	an Institutions (US History) ²	3
Voor 2	Units	16
rear 3 FIRST SEMES	TFR	
CHEM 1A	General Chemistry I	5
PHYS 105	Mathematical Methods in Physics	3
	J	-

<u>PHYS 106</u>	Introduction to Modern Physics	3
<u>PHYS 115</u>	Electronics and Instrumentation	3 - 4
or <u>PHYS 14</u>	<u>5</u> or Optics	
	Units	14- 15
SECOND SEME	STER	10
<u>CHEM 1B</u>	General Chemistry II	5
<u>PHYS 110</u>	Classical Mechanics	3
<u>PHYS 124</u>	Thermodynamics and Statistical Mechanics	3
<u>PHYS 135</u>	Electricity And Magnetism	3
Upper Divis	sion GE Area 3 - Arts or Humanities + Writing Intensive ²	3
	Units	17
Year 4		
FIRST SEMEST		
<u>PHYS 136</u>	Electrodynamics of Waves, Radiation, and Materials	3
<u>PHYS 150</u>	Quantum Mechanics	3
<u>PHYS 156</u>	Classical and Statistical Mechanics	3
Physics Ele	ctive ³	3
Upper Divis Reasoning	sion GE Area 5 or 2 - Science or Mathematical Concepts/Quantitative	3
0	Units	15
SECOND SEME	STER	
<u>PHYS 151</u>	Advanced Modern Physics	3
<u>PHYS 175</u>	Advanced Physics Laboratory	2
<u>PHYS 191</u>	Senior Project	1 - 2
Upper Divis	sion GE Area 4 - Social & Behavioral Sciences 2	3
Elective of (Choice	3
	Units	12- 13
	Total Units	121- 123

While there are savings to be made by finishing in four years, there are situations where it may not be in your best academic interest to do this. If you seek a minor, are not prepared to take Math 30 at the start of your first year, or must work more than fifteen hours per week, a four-year graduation plan is generally not recommended. Most graduates from our program do not graduate in four years due to such circumstances.

Keys to Success

Physics is a challenging major that requires not only the ability to understand complex theories, but also to use advanced mathematics, sophisticated instrumentation, and computers. You must also be able to explain the results unambiguously. Our suggested strategies for success are:

- **Be realistic about time** Being a full-time student is a full-time job. For every hour in class, you should be spending <u>at least</u> 2 hours outside of class studying. For a typical fifteen-unit load, this means that you should be spending over 30 hours a week studying outside of class. If you must work more than 15 hours a week, select your schedule wisely so that you're not overcommitted.
- **Take your math seriously** Be aware that the *first* mathematics course that we require is significantly beyond the minimum University GE requirement. Students who struggle through the calculus series are more likely to struggle in their physics courses. Math (calculus and algebra) is the language of physics; you need to know it thoroughly.
- Practice, practice You will never learn to speak a foreign language without speaking it. Physics is no different. To succeed, you must do problems, lots of them – then do some more. Don't take short cuts using solutions manuals. Don't assume that the algebra that follows the first few steps is trivial; grind them out. If problems are too easy, find harder ones! Challenge yourself!
- **Show up to class** Physics is hard to learn from books alone. Participate in classroom discussions and don't be afraid to ask questions.
- **Team up** Studying in groups and working out problems together is a great way to reinforce what you're learning, if done right. Just sitting in a group and copying what others say is unproductive. Explaining problems to others strengthens your own understanding of the subject.
- Attend the weekly colloquia See how the theories that you're learning in classes are applied in the "real world." Pay attention to how the talks are given: what makes them effective, what makes them ineffective? Use them to think about research opportunities.
- **Get comfortable with computers** Learn how to effectively use software packages like Microsoft Word and Excel. Learn how to make productive tables and graphs: these skills will make you stand out in your career, no matter what it is. As you move along further in your studies, use tools like Mathematica and Wolfram Alpha to check your work or solve problems that are impossible with pencil and paper.
- **No surprises!** While we do our best to keep you informed, ultimately you are responsible for knowing University policies. They can be found in the Catalog: read and understand them. Check your Saclink email (the official email used by the University) frequently for important announcements and updates. By being well-informed, you can avoid issues that may lead to wasted time, extra cost, or unnecessary stress.

Learning Outcomes

Our graduates leave Sacramento State with a broad set of skills that will prepare them for a wide range of career paths, including graduate school, industry or government jobs, or teaching. Our program learning outcomes are:

- Apply scientific reasoning to solve advanced physics problems and design, carry out and analyze hands-on and numerical experiments.
- Communicate physics concepts and particularly their own scientific results in written documents (e.g., senior project reports and research papers).
- Explain physics concepts and particularly their own scientific results through a variety of media, including oral (e.g., presentations, seminars) and visual communication (e.g., graphs, figures, posters).
- Apply scientific reasoning to solve advanced physics problems and/or to design, carry out, and analyze experiments.
- Locate, retrieve, read, draw conclusions, and critically evaluate physics and other related scientific research literature.
- Use physics concepts and mathematics to develop models that describe theoretical and/or experimental results or predict physics phenomena.
- Act with professional integrity and employ scientific ethics in their professional interactions.
- Integrate knowledge of physics concepts, mathematics, and related disciplines when performing their own scientific work.

Flowcharts

Lower Division



Upper Division

