MASTER OF SCIENCE IN ASTRONOMY & ASTROPHYSICS

The Master of Science in Astronomy & Astrophysics involves advanced coursework in classical mechanics, stellar astrophysics, radiative processes in astrophysics, extragalactic astronomy & cosmology, and data and statistical analysis techniques for observational astronomy research. Specialized electives are frequently offered in special & general relativity, plasma physics, and computational physics. Students may select from 3 culminating experience options: a Master's Thesis, a Culminating Project, or a Comprehensive Oral Examination.

Admission to the Program

Most students admitted to the program will have undergraduate degrees in Physics, Astronomy, Astrophysics, or very closely related fields. Ideal preparation includes coursework in calculus through multivariable and vector calculus, differential equations, linear algebra, classical mechanics, electromagnetism, thermodynamics and statistical physics, quantum mechanics, computer programming, an introductory survey of all of astronomy, and some coursework in stellar astronomy, galactic astronomy, and extragalactic astronomy & cosmology.

On the other hand, we welcome students whose undergraduate degrees are outside Physics, Astronomy, Astrophysics, or related fields. Some of our most successful students have had backgrounds in Music, Fine Arts, Psychology, or Economics! However, it is crucial that students from such non-STEM backgrounds still have completed calculus through multivariable and vector calculus and had a thorough calculus-based introductory survey of all of physics. This coursework can be completed at community or junior colleges or extension schools affiliated with universities. Upper-division undergraduate coursework can then be taken at SFSU before taking graduate coursework.

Applications for admission to the graduate program must include:

i. Transcripts from all previous institutions of higher education. The overall GPA or the GPA in the last 60 units of study should be at least 3.0. The GPA in mathematics and physics courses should also be at least 3.0.
ii. Two letters of recommendation from faculty who know your academic record and potential for independent research.
iii. A statement of purpose describing your interest in pursuing graduate study in the Department of Physics and Astronomy at SFSU.

We do not require the GRE General or Subject Tests.

Students whose GPA is slightly below 3.0 should contact the department in advance of applying; it may be possible to petition the Division of Graduate Studies to allow the application.

Students who attended foreign universities in which English was not the primary language of instruction will be required to submit results of the TOEFL, IELTS, or PTE.

Progress toward Degree

Students admitted to the program are initially given the status *"conditionally classified."* This means that you must satisfy certain conditions in your first year in order to be advanced to candidacy for the M.S. degree. Some of these conditions include:

i. Satisfy Writing Proficiency Level 1 – We will ask you to submit a writing sample. If your writing in standard academic English needs further improvement, you will be required to enroll in a writing-intensive class in your first year. Students may also meet this requirement by obtaining a score of at least 4.5 on the GRE Analytic Writing.
ii. Physics & Astronomy Placement Tests – All incoming students must take an open-book physics placement test two weeks before the start of the first semester. Students in astronomy will also take a placement test on undergraduate astronomy. These tests will be reviewed by the Graduate Coordinator who will also review your undergraduate transcripts. You may be strongly advised to enroll in undergraduate courses to strengthen your understanding of the foundations of physics and astronomy before proceeding to graduate coursework.

Please be aware that if you are required to take additional coursework to strengthen your writing skills or improve on your undergraduate physics foundation, you may need more than four semesters to complete the program. Graduate students who do not successfully complete two courses per year toward their Advancement to Candidacy are subject to disqualification.

Graduate students are expected to attend department colloquia and must attend at least five per semester unless excused by the Graduate Coordinator.

Culminating Experience

There are three options for the graduate Culminating Experience requirement:

i. ASTR 895: Culminating Project — Independent and original culminating project in astronomy and astrophysics under faculty supervision leading to written project report and oral defense of the project. Culminating projects could include: development of new teaching/curricular modules, portfolios of science writing/journalism, internships in science museums/planetaria or industrial or national research labs, development of technical reports/manuals for new scientific instruments, etc.
ii. ASTR 898: Master's Thesis — Independent and original experimental, observational, theoretical, or computational research in astronomy and astrophysics under faculty supervision leading to written Master's Thesis and oral defense of the thesis.
iii. ASTR 896EXM: Comprehensive Oral Examination — Comprehensive oral examination on core topics in astronomy and astrophysics.

The written project report for ASTR 895 or the written Master's Thesis for ASTR 898 will satisfy the graduate Writing Proficiency Level 2 requirement. Students who select ASTR 896EXM will need to submit an additional substantial writing assignment to satisfy the Writing Proficiency Level 2 requirement.

Advancement to Candidacy (ATC) and Proposal for Culminating Experience (PCE) forms must be approved by the Division of Graduate Studies before registration for a culminating experience class.

Program Learning Outcomes

Graduates with M.S. Astronomy & Astrophysics degrees will be able to:

a. Describe universal physical principles in classical mechanics, electricity & magnetism, special & general relativity, thermodynamics & statistical mechanics, quantum mechanics, astronomy & astrophysics, and relate fundamental conservation principles (conservation of energy, conservation of linear momentum, conservation of angular momentum) to underlying symmetries of nature.
b. Analyze real-world physical systems on Earth and throughout the Universe, develop simplified models of such systems, translate physical principles into the language of mathematics, and then apply the appropriate mathematical tools (vector calculus, linear algebra, differential equations, variational techniques, probability & statistics, numerical & computational methods) to determine a system's spatiotemporal evolution with an awareness of the limitations of any solutions due to the approximations of the physical models and/or mathematical/computational techniques.
c. Demonstrate proficiency with basic laboratory skills and experimental techniques with electronics, lasers & optical devices, sensors, detectors, microscopes, and telescopes, always with appropriate safety practices (especially with respect to lasers, chemicals, radioactive materials).
d. Articulate and apply the "scientific method," the empirical, iterative method of acquiring new knowledge through developing models to explain observations of the natural world, formulating testable hypotheses, designing and executing experimental, computational, and theoretical investigations to test predictions, analyzing data with appropriate statistics and attention to uncertainties, ascertaining consistency with existing theories, and sharing results with the broader scientific community for confirmation and validation.
e. Demonstrate writing, speaking, and visual data presentation skills to effectively communicate science at the appropriate level of sophistication for the relevant target audience (e.g., instructors, students, scientists, public-at-large, policy-makers).
f. Develop the social and communication skills to effectively participate in diverse scientific teams, including those that are multidisciplinary and/or interdisciplinary, and appreciate that the pursuit of science is a human endeavor and that progress is best made when the full spectrum of humanity is encouraged to participate and share their perspectives, passions, and skills.
g. Engage local, state, national & global communities to address current and emerging scientific and technological challenges in equitable and environmentally sustainable ways.

Astronomy & Astrophysics (M.S.) – 30 units

Core Requirements (15 units)

Code	Title	Units
ASTR 722	Radiative Processes in Astrophysics	3
ASTR 742	Galaxies and Cosmology	3
ASTR 770	Observational Techniques in Astronomy Research	3
ASTR 897	Research [1]	3
PHYS 701	Classical Mechanics	3

[1] Or other similar graduate supervision courses, such as ASTR 899, PHYS 890, PHYS 891, PHYS 897, and PHYS 899. These 3 units can be spread across different semesters.

Culminating Experience (0-3 units)

Select one:

Code	Title	Units
ASTR 895	Culminating Project	3
ASTR 896EXM	Culminating Experience Examination	0
ASTR 898	Master's Thesis	3

ASTR 895 and ASTR 898 both include an oral defense of the project or thesis.

Graduate Physics and Astronomy Electives (6 units)

Select from graduate PHYS and ASTR courses numbered 700 to 799.

Graduate electives that are especially encouraged include:

Code	Title	Units
ASTR 700	Stellar Astrophysics	3
ASTR 798	Astronomy Research Literature	3
PHYS 712	Physics of Plasmas	3
PHYS 725	Special and General Relativity	3
PHYS 740	Computational Physics	3
PHYS 775	Statistical Mechanics	3
PHYS 785	Theoretical Physics	3

General Electives (6-9 units)

Advanced upper-division (numbered 400 and above) or graduate courses (numbered 700 to 885) in physics, astronomy, or appropriately related subjects, selected after advisement and approved by the Graduate Coordinator.

Students who select ASTR 896EXM for their culminating experience must complete 9 units of electives. Students who select ASTR 895 or ASTR 898 for their culminating experience must complete 6 units of electives.

No additional supervision units are allowed. Maximum of 3 units in related fields outside physics & astronomy.

Students who plan to teach as Graduate Teaching Assistants (GTAs) are strongly encouraged to take PHYS 885 (Inclusive Pedagogy for the Physical Sciences).

Credit/No Credit Policy

Major core classes (ASTR 722, ASTR 742, ASTR 770, PHYS 701) and the 6 units of Graduate Physics and Astronomy Electives must be taken for letter grades (except in the event of extraordinary circumstances and with approval of the Graduate Coordinator and/or Department Chair). Up to 9 units of Research, General Electives, and Culminating Experience may be completed with the grade of CR.