The astronomy major serves as the first step toward a career in teaching or research in astronomy. Students majoring in astronomy are strongly encouraged to consider a double major with mathematics or physics.

**Admission to Major**

- a minimum of 32 earned semester credit hours.
- a minimum cumulative GPA of 2.00 ("C").

Contact the department for application procedures.

Many courses in the astronomy program require prerequisites. Students should consult the COURSE DESCRIPTIONS section of this bulletin to determine these courses.

### ASTRONOMY BS

Most professional astronomers hold a doctorate in astronomy or astrophysics; this major is designed to prepare students for graduate studies in these areas.

#### Required General Education (9 credits):
- MATH 121 Calculus I (4)
- PHYS 221 General Physics I (5)

#### Required Support Courses (20 credits):
- MATH 122 Calculus II (4)
- MATH 223 Calculus III (4)
- MATH 321 Ordinary Differential Equations (4)
- PHYS 222 General Physics II (5)
- PHYS 335 Modern Physics I (3)

#### Required for Major (Core, 47 credits):
- AST 201 Spherical Astronomy (2)
- AST 215 Astronomy and Astrophysics I (4)
- AST 225 Astronomy and Astrophysics II (4)
- AST 353 Photometry I (2)
- AST 354 Photometry II (2)
- AST 355 Astrometry (2)
- AST 357 Spectroscopy (2)
- AST 420 Stellar Astrophysics (3)
- AST 421 Stellar Structure (3)
- AST 430 Galactic Structure (3)
- AST 431 Extragalactic Astronomy (3)
- PHYS 441 Mechanics (4)
- PHYS 447 Electricity and Magnetism I (3)
- PHYS 448 Electricity and Magnetism II (3)
- PHYS 461 Quantum Mechanics (4)
- PHYS 465 Computer Applications in Physics (3)

### ASTRONOMY MINOR

#### Required General Education (9 credits):
- MATH 121 Calculus I (4)
- PHYS 221 General Physics I (5)

#### Required Support Courses (Prerequisites, 9 credits):
- MATH 122 Calculus II (4)
- PHYS 222 General Physics II (5)

#### Required for Minor (Core, 13 credits):
- AST 125 Observational Astronomy (3)
- AST 201 Spherical Astronomy (2)
- AST 215 Astronomy and Astrophysics I (4)
- AST 225 Astronomy and Astrophysics II (4)

### POLICIES/INFORMATION

**GPA Policy.** Astronomy majors or minors must maintain a minimum 2.5 GPA in all coursework for their astronomy program, and in addition must earn a "C" or better for a course to apply to their major or minor. These standards apply to the courses required for the degree and their prerequisites. A minimum cumulative GPA of 2.0 is required for graduation. There are no prerequisite GPA requirements for internships.

Refer to the College regarding required advising for students on academic probation.

**P/N Grading Policy.** No more than one-fourth of the total undergraduate degree requirements may be earned in P/NC courses.

**Residency and Transfer Credit.** At least 30 hours of undergraduate credit must be earned at Minnesota State Mankato during the last two academic years.

Students majoring in astronomy have an advisor from their area of interest assigned to them. Questions and concerns pertaining to advising and the assignment of advisors can be answered by Angie B. Bomier, student relations coordinator, TR125 Trafton Science Center, telephone 389-1521.

The astronomers operate two observatories on the southern edge of the campus: Standeford Observatory contains a 14-inch Schmidt-Cassegrain telescope, used for visual observations by general education students and other observatory visitors. Several other 8- to 13-inch telescopes are also available for instructional use by students in Astronomy 125. Andreas Observatory houses a 0.5-meter computer-controlled Cassegrain telescope. This instrument, which is equipped with photographic and electronic cameras and photometers, is used primarily for advanced instruction and faculty research. Standeford Observatory is open regularly for students and other visitors during the spring and the fall. Public viewing nights at Andreas Observatory are held occasionally during the year as weather permits.

### COURSE DESCRIPTIONS

**AST 101 (3) Introduction to Astronomy**

Broad survey of astronomy: the night sky, seasons, moon phases, eclipses, light, telescopes, stars, stellar evolution, galaxies, cosmology, the solar system. Fall, Spring

GE-3

**AST 102 (3) Introduction to the Planets**

Survey of our solar system: the sun, planets, moons, asteroids, comets, and meteors; history of the discovery and exploration of the solar system. Fall, Spring

GE-3

**AST 104 (2) Introduction to Experimental Astronomy**
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Description</th>
<th>Prerequisites</th>
<th>Term(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AST 115 (2)</td>
<td>Life in the Universe</td>
<td>The probability of extraterrestrial intelligent life; the chemical basis of life; planetary environments; habitable zones; the Drake equation; UFOs; space travel; interstellar communication; limits on technical civilizations.</td>
<td>AST 101 or AST 102</td>
<td>Fall, Spring</td>
</tr>
<tr>
<td>AST 125 (3)</td>
<td>Observational Astronomy</td>
<td>Techniques for observing with naked eye, binoculars and small telescopes; constellation and star identification; use of star atlases and handbooks; observations of stars, binaries, clusters, nebulae, etc. Evening observing sessions required.</td>
<td>AST 101 or consent</td>
<td>Fall</td>
</tr>
<tr>
<td>AST 201 (2)</td>
<td>Spherical Astronomy</td>
<td>The celestial sphere; coordinate systems; sidereal and solar time; diurnal motion; precession; proper motion; refraction; aberration; parallax. Requires a background in trigonometry.</td>
<td>AST 101 or consent</td>
<td>Spring</td>
</tr>
<tr>
<td>AST 215 (4)</td>
<td>Astronomy and Astrophysics I</td>
<td>Celestial mechanics; gravitational and tidal forces; stellar motions and parallax; radiation and matter; magnitudes and stellar spectra; binary stars and stellar masses; stellar structure and evolution.</td>
<td>MATH 121 and PHYS 221</td>
<td>Fall</td>
</tr>
<tr>
<td>AST 225 (4)</td>
<td>Astronomy and Astrophysics II</td>
<td>Stellar endpoints; close binary systems; variable stars; the Milky Way; normal galaxies; galactic evolution; active galaxies and quasars; cosmology.</td>
<td>AST 215, MATH 122, PHYS 222</td>
<td>Spring</td>
</tr>
<tr>
<td>AST 294 (1-6)</td>
<td>Workshop</td>
<td>A short course devoted to a specific astronomical topic. May be repeated for credit on each new topic.</td>
<td>Variable</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 351 (1)</td>
<td>Telescope Operations</td>
<td>Telescope optics; operating the 0.5-meter telescope; pointing and guiding; preparation of observing lists and finder charts; operation of the telescope's ancillary equipment.</td>
<td>AST 201 and AST 215, Consent</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 353 (2)</td>
<td>Photometry I</td>
<td>Photometric systems; observational techniques of point-source photometry: methods of data reduction; interpretation of data.</td>
<td>AST 215</td>
<td>ALT-Fall</td>
</tr>
<tr>
<td>AST 354 (2)</td>
<td>Photometry II</td>
<td>Observations of extended sources; photometric calibration of extended sources; use of secondary standard stars.</td>
<td>AST 353</td>
<td>ALT-Spring</td>
</tr>
<tr>
<td>AST 355 (2)</td>
<td>Astrometry</td>
<td>Reduction of digital images to determine positions, proper motions, and parallaxes of stars; analysis of errors.</td>
<td>AST 201 and AST 215</td>
<td>ALT-Spring</td>
</tr>
<tr>
<td>AST 357 (2)</td>
<td>Spectroscopy</td>
<td>Line identification; radial velocity determinations; spectral classification.</td>
<td>AST 225</td>
<td>ALT-Fall</td>
</tr>
<tr>
<td>AST 420 (3)</td>
<td>Stellar Astrophysics</td>
<td>Blackbody radiation; radiative transfer; atomic structure; spectroscopic notation; excitation; ionization; absorption and emission coefficients; line profiles; analysis of stellar spectra.</td>
<td>AST 225 and PHYS 222</td>
<td>ALT-Fall</td>
</tr>
<tr>
<td>AST 421 (3)</td>
<td>Stellar Structure</td>
<td>The gaseous state; degenerate matter; equations of stellar structure; polytropes; models of stellar interiors and atmospheres; stellar evolution; nucleosynthesis; stellar endpoints.</td>
<td>AST 420</td>
<td>ALT-Spring</td>
</tr>
<tr>
<td>AST 430 (3)</td>
<td>Galactic Structure</td>
<td>Structure, kinematics, and dynamics of our galaxy.</td>
<td>AST 225, PHYS 222, MATH 223</td>
<td>ALT-Fall</td>
</tr>
<tr>
<td>AST 431 (3)</td>
<td>Extragalactic Astronomy</td>
<td>Normal galaxies; groups and clusters of galaxies; galaxy interactions and mergers; active galactic nuclei; large-scale structure; galaxy formation and evolution; cosmology.</td>
<td>AST 430</td>
<td>ALT-Spring</td>
</tr>
<tr>
<td>AST 488 (1-4)</td>
<td>Seminar</td>
<td>May be repeated for credit on each new topic.</td>
<td>Consent</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 491 (1-6)</td>
<td>In-Service</td>
<td>A course designed to upgrade the qualifications of persons on-the-job.</td>
<td>Consent</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 493 (1-6)</td>
<td>Undergraduate Research</td>
<td>Students will conduct supervised research in astronomy.</td>
<td>Consent</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 494 (1-6)</td>
<td>Workshop</td>
<td>A short course devoted to a specific astronomical topic. May be repeated for credit on each new topic.</td>
<td>Consent</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 495 (1-4)</td>
<td>Selected Topics</td>
<td>A course in a particular area of astronomy not regularly offered. May be repeated for credit on each new topic.</td>
<td>Consent</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 497 (1-16)</td>
<td>Internship</td>
<td>Provides a student the opportunity to gain expertise and experience in a special field under the supervision of a qualified person.</td>
<td>Consent</td>
<td>Variable</td>
</tr>
<tr>
<td>AST 499 (1-8)</td>
<td>Individual Study</td>
<td>Individual study under the guidance of an astronomy faculty member.</td>
<td>Consent</td>
<td>Fall, Spring</td>
</tr>
</tbody>
</table>