ASTR 100 **Introduction to Astronomy** credit: 3 hours.

One term introduction to astronomy. The nature of science; sun, planets, and moons; origin of the solar system; nature and evolution of stars; exploding stars; stellar remnants, including white dwarfs, neutron stars, and black holes; extrasolar planetary systems; galaxies and quasars; dark matter and dark energy; the Big Bang and the fate of the universe; and life in the universe. Lectures and observation; a field trip to Parkland Staerkel Planetarium may be required, nominal charge. Credit is not given for ASTR 100 if credit in any of ASTR 121, ASTR 122, ASTR 210, or equivalent has been earned. Students with credit in PHYS 211 are encouraged to take ASTR 210.

Students interested in ASTR 100 should also consider ASTR 121 or ASTR 122 which covers the same materials and topics but in two semesters instead of one. ASTR 121 and ASTR 122 include two lectures each week and one weekly small discussion meeting for more individual attention. ASTR 121 and ASTR 122 are independent offerings and can be taken in any order. While ASTR 100, ASTR 121 and ASTR 122 are for non-science majors, problem solving with basic algebra is required. Science and astronomy majors should take ASTR 210.

This course satisfies the General Education Criteria for a:
Nat Sci & Tech - Phys Sciences

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>41827</td>
<td>Lecture</td>
<td>1</td>
<td>01:00 PM - 01:50 PM</td>
<td>MWF</td>
<td>103 - Mumford Hall</td>
<td>Hardegree-Ullman, E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>31278</td>
<td>Lecture</td>
<td>2</td>
<td>02:00 PM - 02:50 PM</td>
<td>MWF</td>
<td>103 - Mumford Hall</td>
<td>Hardegree-Ullman, E</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>58883</td>
<td>Online</td>
<td>OCE</td>
<td>ARRANGED -</td>
<td>-</td>
<td>-</td>
<td>Dunne, B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>58800</td>
<td>Online</td>
<td>ONL</td>
<td>ARRANGED -</td>
<td>-</td>
<td>-</td>
<td>Dunne, B</td>
</tr>
</tbody>
</table>
ASTR 121  **The Solar System**  credit: 3 hours.

Introductory survey of the solar system; structure and motions of the earth and moon; planetary motions; natures and characteristics of the planets, and small solar system bodies (comets and asteroids); planetary moons and rings; meteors, meteoroids, and meteorites; properties of the Sun; origin and evolution of the solar system; comparison of our solar system to extrasolar planetary systems. Emphasis will be placed on problem-solving and scientific methods. Two lectures and one discussion each week, and observing sessions during the term. Credit is not given for ASTR 121 if credit for any of ASTR 100, ASTR 210, GEOL 116 has been earned. Students with credit in PHYS 211 are encouraged to take ASTR 210.

ASTR 121 and ASTR 122 cover the same topics as ASTR 100, but the material and topics are covered in much more depth over two semesters instead of one. ASTR 121 and ASTR 122 are independent offerings and can be taken in any order. While ASTR 121 and ASTR 122 are for non-science majors, problem solving with basic algebra is required. Science and astronomy majors should take ASTR 210. Students must register for one discussion and one lecture section.

This course satisfies the General Education Criteria for:
Quantitative Reasoning II  
Nat Sci & Tech - Phys Sciences

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>37115</td>
<td>Discussion/Recitation</td>
<td>AD1</td>
<td>09:00 AM - 09:50 AM</td>
<td>F</td>
<td>325 - David Kinley Hall</td>
<td>Hardegree-Ullman, E Wavle, D</td>
</tr>
</tbody>
</table>

Physical Sciences, and Quant Reasoning II course.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>37117</td>
<td>Discussion/Recitation</td>
<td>AD2</td>
<td>10:00 AM - 10:50 AM</td>
<td>F</td>
<td>325 - David Kinley Hall</td>
<td>Hardegree-Ullman, E Wavle, D</td>
</tr>
</tbody>
</table>

Physical Sciences, and Quant Reasoning II course.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>37118</td>
<td>Discussion/Recitation</td>
<td>AD3</td>
<td>11:00 AM - 11:50 AM</td>
<td>F</td>
<td>325 - David Kinley Hall</td>
<td>Hardegree-Ullman, E Wavle, D</td>
</tr>
</tbody>
</table>

Physical Sciences, and Quant Reasoning II course.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>37120</td>
<td>Discussion/Recitation</td>
<td>AD4</td>
<td>12:00 PM - 12:50 PM</td>
<td>F</td>
<td>325 - David Kinley Hall</td>
<td>Hardegree-Ullman, E Holgado, A</td>
</tr>
</tbody>
</table>

Physical Sciences, and Quant Reasoning II course.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>37122</td>
<td>Discussion/Recitation</td>
<td>AD5</td>
<td>01:00 PM - 01:50 PM</td>
<td>F</td>
<td>325 - David Kinley Hall</td>
<td>Hardegree-Ullman, E Holgado, A</td>
</tr>
</tbody>
</table>

Physical Sciences, and Quant Reasoning II course.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>37124</td>
<td>Discussion/Recitation</td>
<td>AD6</td>
<td>02:00 PM - 02:50 PM</td>
<td>F</td>
<td>325 - David Kinley Hall</td>
<td>Hardegree-Ullman, E Holgado, A</td>
</tr>
</tbody>
</table>
ASTR 122  **Stars and Galaxies**  credit: 3 hours.
Introduction to celestial objects and phenomena beyond the solar system, and the governing basic physical principles: galaxies, quasars, and structure of the universe; dark matter and dark energy; the Big Bang and the fate of the universe; the Milky Way; the interstellar medium and the birth of stars; distances, motions, radiation, structure, evolution, and death of stars, including neutron stars and black holes. Emphasis will be placed on problem-solving and scientific methods. Two lectures and one discussion each week, and observing sessions during the term. Credit is not given for ASTR 122 if credit in either ASTR 100 or ASTR 210 has been earned. Students with credit in PHYS 211 are encouraged to take ASTR 210.
ASTR 121 and ASTR 122 cover the same topics as ASTR 100, but the material and topics are covered in much more depth over two semesters instead of one. ASTR 121 and ASTR 122 are independent offerings and can be taken in any order. While ASTR 121 and ASTR 122 are for non-science majors, problems solving with basic algebra is required. Science and astronomy majors should take ASTR 210.
This course satisfies the General Education Criteria for a:
Quantitative Reasoning II
Nat Sci & Tech - Phys Sciences

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>39753</td>
<td>Discussion/Recitation</td>
<td>AD1</td>
<td>09:00 AM - 09:50 AM</td>
<td>F</td>
<td>170 - Wohlers Hall</td>
<td>Dunne, B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Miller, J</td>
</tr>
<tr>
<td>39754</td>
<td>Discussion/Recitation</td>
<td>AD2</td>
<td>10:00 AM - 10:50 AM</td>
<td>F</td>
<td>170 - Wohlers Hall</td>
<td>Dunne, B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ertel, A</td>
</tr>
<tr>
<td>39755</td>
<td>Discussion/Recitation</td>
<td>AD3</td>
<td>11:00 AM - 11:50 AM</td>
<td>F</td>
<td>170 - Wohlers Hall</td>
<td>Dunne, B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ertel, A</td>
</tr>
<tr>
<td>39756</td>
<td>Discussion/Recitation</td>
<td>AD4</td>
<td>12:00 PM - 12:50 PM</td>
<td>F</td>
<td>170 - Wohlers Hall</td>
<td>Dunne, B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ertel, A</td>
</tr>
<tr>
<td>39749</td>
<td>Discussion/Recitation</td>
<td>AD5</td>
<td>02:00 PM - 02:50 PM</td>
<td>F</td>
<td>170 - Wohlers Hall</td>
<td>Dunne, B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Miller, J</td>
</tr>
<tr>
<td>39748</td>
<td>Discussion/Recitation</td>
<td>AD6</td>
<td>01:00 PM - 01:50 PM</td>
<td>F</td>
<td>170 - Wohlers Hall</td>
<td>Dunne, B</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Miller, J</td>
</tr>
<tr>
<td>Course</td>
<td>Title</td>
<td>Credits</td>
<td>CRN</td>
<td>Type</td>
<td>Section</td>
<td>Time</td>
</tr>
<tr>
<td>----------</td>
<td>---------------------------</td>
<td>---------</td>
<td>-------</td>
<td>--------------</td>
<td>---------</td>
<td>--------------------</td>
</tr>
<tr>
<td>39757</td>
<td>Discussion/Recitation AD7</td>
<td>F</td>
<td>02:00 PM - 02:50 PM</td>
<td>F</td>
<td>134 - Astronomy Building</td>
<td>Dunne, B</td>
</tr>
<tr>
<td></td>
<td>Physical Sciences, and Quant Reasoning II course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39752</td>
<td>Lecture AL1</td>
<td>02:00 PM - 02:50 PM</td>
<td>MW</td>
<td>101 - Armory</td>
<td>Dunne, B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Physical Sciences, and Quant Reasoning II course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39750</td>
<td>Lecture H</td>
<td>09:00 AM - 09:50 AM</td>
<td>MWF</td>
<td>134 - Astronomy Building</td>
<td>Kemball, A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Camp Honors/Chanc Schol, Physical Sciences, and Quant Reasoning II course.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>For Chancellor's Scholars; others may enroll with consent of instructor and Director of the Campus Honors Program. Restricted to Chancellor's Scholar-CHPHonors students.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**ASTR 131 The Solar System Lab**  credit: 1 hours.
Laboratory studies which complement the lecture course, ASTR 121. Laboratory exercises will include properties of telescopes, observations of the Moon and planets using telescopes at the Campus Observatory, and computer-based activities that illustrate modern astronomical techniques using digital data. Prerequisite: Credit in ASTR 100 or ASTR 121, or concurrent registration in ASTR 121.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>55702</td>
<td>Laboratory</td>
<td>1</td>
<td>07:00 PM - 10:00 PM</td>
<td>M</td>
<td>-</td>
<td>Dunne, B Wen, D</td>
</tr>
</tbody>
</table>

Class will be held in 289 UGL. ASTR 131: The Solar System Lab Second 8 week course: Laboratory studies which complement the lecture course, ASTR 121, The Solar System. Laboratory exercises will include properties of telescopes, observations of the Moon and planets using telescopes at the Campus Observatory, and computer-based activities that illustrate modern astronomical techniques using digital data. Prerequisite: Credit in ASTR 100 or ASTR 121, or concurrent registration in ASTR 121. ASTR 131 meets only during part of the term; check the meeting dates.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>55704</td>
<td>Laboratory</td>
<td>3</td>
<td>07:00 PM - 10:00 PM</td>
<td>W</td>
<td>-</td>
<td>Dunne, B Wen, D</td>
</tr>
</tbody>
</table>

Class will be held in 289 UGL ASTR 131: The Solar System Lab Second 8 week course: Laboratory studies which complement the lecture course, ASTR 121, The Solar System. Laboratory exercises will include properties of telescopes, observations of the Moon and planets using telescopes at the Campus Observatory, and computer-based activities that illustrate modern astronomical techniques using digital data. Prerequisite: Credit in ASTR 100 or ASTR 121, or concurrent registration in ASTR 121. ASTR 131 meets only during part of the term; check the meeting dates.

**ASTR 132 Stars and Galaxies Lab**  credit: 1 hours.
Laboratory studies which complement the lecture course, ASTR 122. Laboratory exercises will include properties of telescopes, observations of star clusters, nebulae and galaxies using telescopes at the Campus Observatory, and computer-based activities that illustrate modern astronomical techniques using digital data. Prerequisite: Credit in ASTR 100 or ASTR 122, or concurrent registration in ASTR 122.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
</table>
Laboratory 1
07:00 PM - 10:00 PM
T
Class will be held in 289 UGL. ASTR 132: Stars & Galaxies Lab First 8 week course: Laboratory studies which complement the lecture course, ASTR 122. Laboratory exercises will include properties of telescopes, observations of star clusters, nebulae and galaxies using telescopes at the Campus Observatory, and computer-based activities that illustrate modern astronomical techniques using digital data. Prerequisite: Credit in ASTR 100 or ASTR 122, or concurrent registration in ASTR 122. ASTR 132 meets only during part of the term; check the meeting dates.

Laboratory 3
07:00 PM - 10:00 PM
R
Class will be held in 289 UGL. ASTR 132: Stars & Galaxies Lab First 8 week course: Laboratory studies which complement the lecture course, ASTR 122, The Solar System. Laboratory exercises will include properties of telescopes, observations of the Moon and planets using telescopes at the Campus Observatory, and computer-based activities that illustrate modern astronomical techniques using digital data. Prerequisite: Credit in ASTR 100 or ASTR 122, or concurrent registration in ASTR 122. ASTR 132 meets only during part of the term; check the meeting dates.

ASTR 199  Undergraduate Open Seminar  credit: 1 TO 5 hours.
Approved for both letter and S/U grading. May be repeated.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>10395</td>
<td>Independent Study</td>
<td>ARRANGED -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Instructor Approval Required

ASTR 210  Introduction to Astrophysics  credit: 3 hours.
Survey of modern astronomy for students with background in physics. Topics include: the solar system; nature and evolution of stars; white dwarfs, neutron stars, and black holes; galaxies, quasars and dark matter; large scale structure of the universe; the Big Bang; and Inflation. Emphasis will be on the physical principles underlying the astronomical phenomena. Prerequisite: PHYS 211.
This course satisfies the General Education Criteria for a: Nat Sci & Tech - Phys Sciences

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>30268</td>
<td>Lecture</td>
<td>1</td>
<td>11:00 AM - 11:50 AM</td>
<td>MWF</td>
<td>1002 - Lincoln Hall</td>
<td>Wong, T</td>
</tr>
</tbody>
</table>

Physical Sciences course.

ASTR 390  Individual Study  credit: 0 TO 4 hours.
Individual study at an advanced undergraduate level. May be repeated in separate terms to a maximum of 8 hours. Prerequisite: Consent of advisor and of faculty member who supervises the work.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>10396</td>
<td>Independent Study</td>
<td>ARRANGED -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Instructor Approval Required
ASTR 401  **Scientific Writing for Astro**  credit: 1 hours.
Development of journal-style writing skills. Papers written in accordance with the Astrophysical Journal Manual of Style on topics approved by the instructor. Emphasis on developing adequate and critical coverage of the topic, brevity compatible with clarity, and effective presentation. Proper referencing, footnotes, and bibliography are covered. 1 undergraduate hour, 1 graduate hour. Prerequisite: Completion of campus Composition I general education requirement. Concurrent enrollment in a designated 400-level astronomy course.

This course satisfies the General Education Criteria for a:
Advanced Composition

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>30271</td>
<td>Conference</td>
<td>C1</td>
<td>ARRANGED -</td>
<td></td>
<td></td>
<td>Foley, R</td>
</tr>
</tbody>
</table>

Advanced Composition course.
Restricted to students in the Astronomy department.
Restricted to Astronomy major(s).
Composition II course meeting with ASTR 404. This course is limited to students with Astronomy as a first or second major. Non-majors who wish to take the course can be enrolled with the instructor's consent.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>54196</td>
<td>Conference</td>
<td>C2</td>
<td>ARRANGED -</td>
<td></td>
<td></td>
<td>Brunner, R</td>
</tr>
</tbody>
</table>

Advanced Composition course.
Restricted to students in the Astronomy department.
Restricted to Astronomy major(s).
Composition II course meeting with ASTR 406. This course is limited to students with Astronomy as a first or second major. Non-majors who wish to take the course can be enrolled with the instructor's consent.

ASTR 404  **Stellar Astrophysics**  credit: 3 hours.
Introduction to astrophysical problems, with emphasis on underlying physical principles; includes the nature of stars, equations of state, stellar energy generation, stellar structure and evolution, astrophysical neutrinos, binary stars, white dwarfs, neutron stars and pulsars, and novae and supernovae. 3 undergraduate hours. 3 graduate hours. Prerequisite: PHYS 212; or consent of instructor. Recommended: ASTR 210, PHYS 213, PHYS 214.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>39758</td>
<td>Lecture</td>
<td>1</td>
<td>01:00 PM - 01:50 PM</td>
<td>MWF</td>
<td>134 - Astronomy Building</td>
<td>Foley, R</td>
</tr>
</tbody>
</table>

ASTR 406  **Galaxies and the Universe**  credit: 3 hours.
Nature of the Milky Way galaxy: stellar statistics and distributions, stellar populations, spiral structure, the nucleus and halo. Nature of ordinary galaxies; galaxies in our Local Group, structure of voids and superclusters. Nature of peculiar objects: Seyfert galaxies, starburst galaxies, and quasars. Elementary aspects of physical cosmology. 3 undergraduate hours. 3 graduate hours. Prerequisite: PHYS 212; or consent of instructor. Recommended: ASTR 210, PHYS 213, PHYS 214.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>43268</td>
<td>Lecture</td>
<td>100</td>
<td>11:00 AM - 11:50 AM</td>
<td>MWF</td>
<td>134 - Astronomy Building</td>
<td>Brunner, R</td>
</tr>
</tbody>
</table>
ASTR 450  **Astrochemistry**  credit: 4 hours.
Same as CHEM 450. See CHEM 450.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>51085</td>
<td>Lecture-Discussion</td>
<td>A</td>
<td>02:00 PM - 03:20 PM</td>
<td>TR</td>
<td>165 - Noyes Laboratory</td>
<td>Woon, D</td>
</tr>
</tbody>
</table>

ASTR 490  **Senior Thesis**  credit: 3 hours.
Research with thesis, under the direction of a senior staff member in astronomy. This course is recommended for all students who plan to do research and graduate study, and it is a prerequisite for graduation with highest distinction in astronomy. In the term preceding their initial enrollment, those interested in taking the course should consult with their advisers and with the undergraduate adviser for the area of interest in which they plan to work. A thesis must be presented for credit to be received. 3 undergraduate hours. No graduate credit. Prerequisite: Two 400-level Astronomy courses. Consent of advisor and of staff member who supervises the work. Astronomy majors of senior standing.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>65690</td>
<td>Independent Study</td>
<td></td>
<td>ARRANGED</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Departmental Approval Required

ASTR 496  **Seminar in Astronomy**  credit: 1 TO 4 hours.
Lectures on topics of current interest in astronomy and astrophysics; for advanced undergraduates and graduates. See Class Schedule for current topics. 1 to 4 undergraduate hours. 1 to 4 graduate hours. Approved for both letter and S/U grading. May be repeated. Prerequisite: Consent of instructor.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>54363</td>
<td>Lecture</td>
<td>APA</td>
<td>04:00 PM - 04:50 PM</td>
<td>R</td>
<td>-</td>
<td>Fields, B</td>
</tr>
</tbody>
</table>

Credit Hours: 1 hours
The Art and Practice of Astronomy Advanced undergraduates are welcome but should seek permission of an instructor. This course will introduce students to some of the tools, opportunities, expectations, and challenges of a career in astronomy and astrophysics research. For about half of the class meetings, students will collaborate interactively to address open-ended research questions qualitatively and quantitatively, using order-of-magnitude and dimensional analyses. The rest of the course meetings will focus on professional preparation and skills, including: scientific writing, oral presentation skills, building a curriculum vitae, postdoctoral fellowships, faculty and research positions, grantsmanship, and ethics. This course is open to graduate students and senior undergraduates with interests in astronomy, astrophysics, and/or cosmology.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>65200</td>
<td>Lecture</td>
<td>OBS</td>
<td>02:00 PM - 03:20 PM</td>
<td>MW</td>
<td>134 - Astronomy Building</td>
<td>Looney, L</td>
</tr>
</tbody>
</table>

Credit Hours: 4 hours
Star Formation
ASTR 496 OBS: Observational ISM and Star Formation Advanced undergraduates with an interest in astronomy and star formation can take this course under ASTR 496. Cross-listed with ASTR 505. This course provides a survey of the current status of observational star formation. Particular emphasis will be placed on making and interpreting physical measurements and how they
relate to our understanding of star formation. Specifically, this course will discuss the general Interstellar Medium, molecular clouds, low-mass star formation, high-mass star formation, and young clusters.

<table>
<thead>
<tr>
<th>Credit Hours: 3 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundations of Data Science</td>
</tr>
<tr>
<td>Restricted to Physics or Astronomy major(s) or minor(s). Not intended for students with Freshman class standing.</td>
</tr>
</tbody>
</table>
| Foundations of Data Science This class is an asynchronous, online course. This course will build a practical foundation for data science by teaching students basic tools and techniques that can scale to large computational systems and massive data sets. Students will first learn how to work at a Unix command prompt before learning about source code control software like git and the github site. Next, the Python programming language will be covered, with a focus on specific aspects of the language and associated Python modules that are relevant for Data Science. Python will be introduced and used primarily via the IPython (or Jupyter) Notebooks, and will cover the Numpy, Scipy, MatPlotlib, Pandas, Seaborn, and scikit_learn Python modules. These capabilities will be demonstrated through simple data science tasks such as obtaining data, cleaning data, visualizing data, and basic data analysis. Students must have access to a fairly modern computer, ideally that supports hardware virtualization, on which they can install software. This section is open to sophomore, juniors, seniors, and graduate students in Astronomy or Physics. Students in other disciplines should enroll in the course as INFO 490 RB (CRN: 65222).

### ASTR 499  Astronomy Laboratory credit: 2 hours.
 Provides hands-on observational experience: how to use a telescope, how to image sources using a modern CCD camera, how to use a modern CCD spectrometer, and how to apply data analysis to astrophysical problems. 2 undergraduate hours. 2 graduate hours. Prerequisite: One 400-level astronomy course.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>55699</td>
<td>Laboratory</td>
<td>AL</td>
<td>08:00 PM - 11:00 PM</td>
<td>W</td>
<td>-</td>
<td>Looney, L</td>
</tr>
</tbody>
</table>

Astr 499: Astronomy Laboratory - held in 124 Observatory. Provides hands-on observational experience: how to use a telescope, how to image sources using a modern CCD camera, how to use a modern CCD spectrometer, and how to use data to make an analytical analysis of astrophysical problems. Prerequisite: One 400-level Astronomy course.

### ASTR 502  Astrophysical Dynamics credit: 4 hours.
 Introduction to stellar dynamics and fluid dynamics. Topics include two body collisions, two body relaxation, potential theory for stellar systems, adiabatic invariance, stellar system models, Jeans equations, and the virial theorem. Also hydrodynamics, magneto-hydrodynamics, waves, instabilities, shocks, explosions, density waves, and wind-blown bubbles. Prerequisite: PHYS 436, PHYS 427, and PHYS 486; or consent of instructor.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>39759</td>
<td>Lecture</td>
<td>1</td>
<td>02:00 PM - 03:20 PM</td>
<td>TR</td>
<td>134 - Astronomy Building</td>
<td>Ricker, P</td>
</tr>
</tbody>
</table>

Astrophysics Dynamics Introduction to stellar dynamics and fluid dynamics. Topics include two body collisions, two body relaxation, potential theory for stellar systems, adiabatic invariance, stellar system models, Jeans equations, and the virial theorem. Also hydrodynamics, magneto-hydrodynamics, waves, instabilities, shocks, explosions, density waves, and wind-blown bubbles. Prerequisite: PHYS 436, PHYS 427, and PHYS 486; or consent of instructor.

### ASTR 505  Star Formation credit: 4 hours.
 Survey of the current state of astrophysical research into the topic of star formation. Particular emphasis placed on interpreting observations and how they relate to the theory of star formation. Prerequisite: ASTR 405 or consent of instructor.
## ASTR 515  General Relativity I  credit: 4 hours.
Same as PHYS 515. See PHYS 515.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>34932</td>
<td>Lecture</td>
<td>A</td>
<td>12:30 PM - 01:50 PM</td>
<td>TR</td>
<td>144 - Loomis Laboratory</td>
<td>Shapiro, S</td>
</tr>
</tbody>
</table>

Restricted to Graduate - Urbana-Champaign.

## ASTR 540  Astrophysics  credit: 4 hours.
Same as PHYS 540. See PHYS 540.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>53893</td>
<td>Lecture</td>
<td>A</td>
<td>12:30 PM - 01:50 PM</td>
<td>TR</td>
<td>136 - Loomis Laboratory</td>
<td>Mouschovias, T</td>
</tr>
</tbody>
</table>

Restricted to Graduate - Urbana-Champaign.

## ASTR 590  Individual Study  credit: 2 TO 16 hours.
Individual study or non-thesis research. May be repeated. Prerequisite: Consent of adviser and of faculty member who supervises the work.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>10399</td>
<td>Independent Study</td>
<td>ARRANGED</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Instructor Approval Required

## ASTR 596  Seminar in Special Topics  credit: 0 TO 16 hours.
Approved for both letter and S/U grading. May be repeated. Prerequisite: Consent of instructor.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>54365</td>
<td>Lecture</td>
<td>APA</td>
<td>04:00 PM - 04:50 PM</td>
<td>R</td>
<td>-</td>
<td>Fields, B</td>
</tr>
</tbody>
</table>

Credit Hours: 1 hours
The Art and Practice of Astronomy This course is open to graduate students and senior undergraduates with interests in astronomy, astrophysics, and/or cosmology. This course will introduce students to some of the tools, opportunities, expectations, and challenges of a career in astronomy and astrophysics research. For about half of the class meetings, students will collaborate interactively to address open-ended research questions qualitatively and quantitatively, using order-of-magnitude and dimensional analyses. The rest of the course meetings will focus on professional preparation and skills, including: scientific writing, oral presentation skills, building a curriculum vitae, postdoctoral fellowships, faculty and research positions, grantsmanship, and ethics. Advanced undergraduates are welcome but should seek permission of an instructor.
This course will introduce students to a variety of common statistical and machine learning algorithms, with an emphasis on practicality. Example topics include regression, random forests, clustering, and dimensional reduction. Students will be expected to participate in discussion about algorithms, their benefits and weaknesses, and their practical application. Section meets for one hour each week. S/U grading only.

ASTR 599  **Thesis Research**  credit: 0 TO 16 hours.
Approved for S/U grading only. May be repeated.

<table>
<thead>
<tr>
<th>CRN</th>
<th>Type</th>
<th>Section</th>
<th>Time</th>
<th>Days</th>
<th>Location</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>10387</td>
<td>Independent Study</td>
<td>ARRANGED</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Instructor Approval Required