TTU Department of Physics and Astronomy

Undergraduate Handbook – 2015-2016 Catalog

This handbook is designed to serve as a guide for the physics major. Only students who enter the College of Arts & Sciences in the 2015-2016 academic year or earlier will be under the guidelines of this booklet.

Advisor Contact Points

The undergraduate advisor for the Department of Physics and Astronomy is Associate Professor of Physics and Director of Undergraduate Programs, Dr. Wallace Glab. To discuss a major, minor, or courses in physics contact him at the following:

Dr. Wallace Glab
Science 120A
(806) 834-1655
wallace.glab@ttu.edu (email contact preferred)

Dr. Melanie Ungar
Assistant Advisor
Science 120B
(806) 834-3994
melanie.ungar@ttu.edu (email contact preferred)

Physics and Astronomy Department Office
Science 101
(806) 742-3767
fax (806) 742-1182

http://www.depts.ttu.edu/phas/

“Like” us on Facebook at TTU Physics Undergraduate Programs and Texas Tech Society of Physics Students (SPS)

Revised 5/31/2018.
Texas Tech University
Department of Physics and Astronomy
Undergraduate Programs

Horn Professor: Estreicher; Bucy Professor: Wigmans; Professors: Akchurin, Duncan, Grave de Peralta, Huang, Lee, Maccarone, Myles, Owen, and Romano; Associate Professors: Corsi, Gibson, Glab, Kunori, Lamp, Sanati, Thacker, and Volobouev; Assistant Professors: Scaringi, Whitbeck; Instructors: Morehead, West.

The Bachelor of Science degree can be taken in any of three areas of concentration, to be described below. These concentrations allow a student to tailor their studies towards their particular career goals. A physics major must declare a concentration when they file a degree plan upon completing 45 hours of coursework.

Majors in this department are required to maintain a minimum grade point average of 2.5 in physics courses and required mathematics adjunct courses and receive a C or better in each of these courses. Students also have a variety of University and College of Arts & Sciences requirements that must be met. The minimum number of hours to attain a degree in physics in each of the various concentrations is 120. Credit for any transferred physics hours will be handled on an individual basis with the department’s undergraduate advisor and the Transfer Evaluation Office. Students transferring into physics from another department or college must have and maintain an institutional grade point average of 2.5 or better to enter and remain in the program, beginning in Spring 2019.

Students are strongly encouraged to devote time to undergraduate research. Research areas in the department include astrophysics, biophysics, condensed matter physics (including nanotechnology), nuclear physics, physics education, and particle physics.

The physics B.S. curricula are designed around the assumption that physics students will minor in mathematics. However, a variety of other minors that complement study in physics can be selected. Choice of a minor other than mathematics may require that a student complete more than 120 hours for their degree.

B.S. in Physics, Professional Concentration

The professional concentration provides a traditional curriculum for students majoring in physics and is intended to prepare them for graduate study or employment in the private or government sector as a physicist. A typical sequence of courses begins with PHYS 1408, 2401, 2402 (now 3301+3101), and 2305 for a total of 15 hours at the introductory level. PHYS 1408 and 2401 have special sections for physics majors, and majors are expected to take these sections. These are usually followed by the intermediate and advanced sequences, PHYS 3304, 3305, 3306, 3401, 4302, 4304, and 4307. Two 3-hour physics elective courses are also required. Students desiring to pursue advanced degrees are recommended to take advanced topic courses. Students are strongly encouraged to devote time to undergraduate research and sign up for 3 hours of PHYS 3000 to earn credit hours for their research. Three hours of PHYS 3000 can count as a PHYS elective.
B.S. in Physics, Astrophysics Concentration

The astrophysics concentration is a variation of the professional concentration and is intended for students who have a particular interest in astronomy and astrophysics. In addition to preparing students for possible employment paths associated with the professional concentration, the astrophysics concentration will prepare students to pursue graduate study in astronomy or astrophysics. This concentration has physics course requirements very similar to the professional concentration, but it also includes 14 hours of ASTR courses in addition to PHYS 3302 and PHYS 4312. Majors in this concentration are strongly encouraged to minor in mathematics. Choice of a different minor will result in a student needing to take more than 120 hours to complete their degree. Students are strongly encouraged to devote time to undergraduate research.

B.S. in Physics, Applied Physics Concentration

The applied physics concentration is a variation of the professional concentration for students who wish to pursue more applied work, such as graduate study or employment in engineering or other technical fields. It requires the same physics coursework as the professional option, with an additional 9 required hours in an applied specialty or specialties. Applied electives must be approved by the physics undergraduate advisor. Again, majors in this concentration are strongly encouraged to minor in mathematics. Choice of a different minor will result in a student needing to take more than 120 hours to complete their degree. Students are strongly encouraged to devote time to undergraduate research.

Required Mathematics Courses for Physics Majors:

The required mathematics courses for physics majors in all three concentrations are MATH 1451, 1452, 2450, 3350, and 3351. MATH 3354 AND 4354 or PHYS 4325 and 4326 may be substituted for MATH 3350 and 3351, and starting in 2017, PHYS 4325 AND 4326 are the preferred differential equations courses for physics majors. MATH 2360 (Linear Algebra) is strongly recommended and required for a MATH minor. Please note that the differential equations sequence will count towards a math minor. Students planning to pursue an advanced degree in physics should consult the physics undergraduate advisor about appropriate additional courses.

Minors for Physics Majors:

A broad variety of minor subjects may be chosen by a student majoring in physics. These include mathematics, biochemistry, physical chemistry, geophysics, computer science, business, and electrical engineering. A frequent minor choice for physics majors is mathematics, the requirements for which are automatically satisfied by the sequence of MATH courses required for the physics major (plus MATH 2360 Linear Algebra). Students contemplating minors outside of the College of Arts & Sciences should seek the advice of the physics undergraduate advisor before beginning that minor.
Minor in Physics

A minor in physics requires 18 semester hours, of which at least 6 must be at the 3000 level or higher and must be approved by the undergraduate advisor. The minor sequence is PHYS 1408, 2401, and 2402 (now 3301+3101) plus 6 hours of approved 3000/4000 level courses. It should be noted that the first three courses have Calculus I, II, and III as prerequisites. Students must receive a grade of C or better in all courses applied toward a minor. The astronomy courses ASTR 1400 and 1401 may not be used to satisfy requirements for the physics major or minor (with the exception of 1400 or 1401 for astrophysics majors).

Minor in Astronomy

A minor in astronomy by students majoring in subjects other than physics requires at least 21 semester hours of physics and astronomy courses, at least 9 of which must be at the 3000 or higher level and which must be approved by the undergraduate advisor. The recommended sequence is PHYS 1408, PHYS 2401, PHYS 2402 (now 3301+3101) with additional credits selected from among ASTR 2401, ASTR 4301, ASTR 4302, PHYS 3302 (no longer offered), and undergraduate research in astronomy (PHYS 3000). It should be noted that the first three courses have Calculus I, II, and III as prerequisites. Under some circumstances, courses in engineering, geosciences or mathematics with significant astronomy content may be taken in place of the courses listed here.

Society of Physics Students (SPS)

Students are strongly encouraged to participate in the Society of Physics Students, which sponsors several academic and social activities. SPS is headquartered in Room 004 of the Science building, and its members provide free tutoring for fellow students and organize many fun and/or educational events and trips.
Physics Major
Degree Requirements

General Education Requirements – College of Arts & Sciences

English (12 hours)  ENGL 1301  ENGL 1302  ENGL 23--  ENGL 23--

Oral Communication (3 hours)

Mathematics (6 hours)  MATH 1451  MATH 1452

Life and Physical Sciences (8 hours)  PHYS 1408  PHYS 2401

United States History (6 hours)  HIST 2300  HIST 2301 -OR- HIST 2310

Political Science (6 hours)  POLS 1301  POLS 2302 (now POLS 2306)

Social and Behavioral Sciences (3 hours)

Language, Philosophy, and Culture (3 hours)

Creative Arts (3 hours)

Multicultural (3 hours)

Personal Fitness and Wellness (2 hours)

Foreign Language: Freshman proficiency plus 6 hours at the sophomore level or higher in the same language. (Students who wish to take Spanish should take the Spanish Placement Exam.)

40 Credits Required at the Junior/Senior Level

120 Credits Required Total

This menu of courses is required by Texas Tech University for any student seeking a B.S. degree in the College of Arts & Sciences. The basic pattern is defined by the state and SACS. Courses for the various categories can be found under “Undergraduate Academics” on page 59 in the 2015-2016 Catalog.

Writing Intensive Requirement: Regardless of concentration, a physics major must take at least 2 courses with the Writing Intensive (WI) attribute within the major. Writing Intensive (WI) courses (marked with an asterisk below) will be aimed towards providing and assessing student abilities in written communication of scientific information in the specific ways that are common to professional physicists and astrophysicists, both in traditional and non-traditional positions.
Physics Major, Professional Concentration

Required Physics Courses (37 hours)

- PHYS 1408 Principles I- Mechanics
- PHYS 2401 Principles II- E&M
- PHYS 2305 Computation for the Physical Sciences
- PHYS 2402 Principles III (renamed and renumbered)
  ➢ now PHYS 3301 Principles IV + PHYS 3101 Legacy Modern Physics Lab
- PHYS 3304 Intermediate Experimental Physics (Writing Intensive)*
- PHYS 3305 E&M I
- PHYS 3306 E&M II
- PHYS 3401 Optics (Writing Intensive)*
- PHYS 4302 Statistical
- PHYS 4304 Mechanics
- PHYS 4307 Quantum Mechanics I

Physics Electives (choose 6 or more hours)

- PHYS 3000 Undergraduate Research
- PHYS 3302 Cosmophysics (no longer offered)
- PHYS 4000 Independent Study
- PHYS 4301 Computational
- PHYS 4306 Senior Project (Writing Intensive)*
- PHYS 4308 Quantum Mechanics II
- PHYS 4309 Solid State
- PHYS 4312 Nuclear and Particle
- ASTR 4301 Astrophysics I
- ASTR 4302 Astrophysics II

Required Mathematics Courses (18 hours)

- MATH 1451 Calculus I
- MATH 1452 Calculus II
- MATH 2450 Calculus III
- PHYS 4325 -OR- MATH 3350 -OR- MATH 3354
- PHYS 4326 -OR- MATH 3351 -OR- MATH 4354

Students are strongly encouraged to take MATH 2360 (Linear Algebra) to complete a MATH minor.
Physics Major, Astrophysics Concentration

**Required Physics Courses (39 or 40 hours)**

- PHYS 1408 Principles I- Mechanics
- PHYS 2401 Principles II- E&M
- PHYS 2305 Computation for the Physical Sciences
- PHYS 2402 Principles III (renamed and renumbered)
  - now PHYS 3301 Principles IV + PHYS 3101 Legacy Modern Physics Lab
- PHYS 3302 Cosmophysics (no longer offered)
  - can be satisfied by PHYS 3000 Undergraduate Research (3 hours)
- PHYS 3304 Intermediate Experimental Physics (Writing Intensive)*
- PHYS 3305 E&M I
- PHYS 3401 Optics* -OR- PHYS 3306 E&M II (Optics is a Writing Intensive course)
- PHYS 4302 Statistical
- PHYS 4304 Mechanics
- PHYS 4307 Quantum Mechanics I
- PHYS 4312 Nuclear and Particle Physics

**Required Astronomy Courses (14 hours)**

- ASTR 1401 Stellar Astronomy
- ASTR 2401 Observational Astronomy
- ASTR 4301 Astrophysics I
- ASTR 4302 Astrophysics II

**Required Mathematics Courses (18 hours)**

- MATH 1451 Calculus I
- MATH 1452 Calculus II
- MATH 2450 Calculus III
- PHYS 4325 -OR- MATH 3350 -OR- MATH 3354
- PHYS 4326 -OR- MATH 3351 -OR- MATH 4354

Students are strongly encouraged to take MATH 2360 (Linear Algebra) to complete a MATH minor.
Physics Major, Applied Physics Concentration

**Required Physics Courses (37 hours)**

- PHYS 1408 Principles I- Mechanics
- PHYS 2401 Principles II- E&M
- PHYS 2305 Computation for the Physical Sciences
- PHYS 2402 Principles III (renamed and renumbered)
  - now PHYS 3301 Principles IV + PHYS 3101 Legacy Modern Physics Lab
- PHYS 3304 Intermediate Experimental Physics (Writing Intensive)*
- PHYS 3305 E&M I
- PHYS 3306 E&M II
- PHYS 3401 Optics (Writing Intensive)*
- PHYS 4302 Statistical
- PHYS 4304 Mechanics
- PHYS 4307 Quantum Mechanics I

**Applied Physics or Engineering Electives (choose 9 or more hours)**

- Pre-approved ECE courses: ECE 3302, 3303, 3311, 3312, 4314, 4341, 4344, 4354, 4381
- Pre-approved Geophysics courses: GPH 3300, 3310, 4300, 4321, 4323
- Pre-approved Wind Energy courses: WE 1300, 1310, 3300, 3301, 4322, 4321

**Physics Electives (choose 6 or more hours)**

- PHYS 3000 Undergraduate Research
- PHYS 3302 Cosmophysics (no longer offered)
- PHYS 4000 Independent Study
- PHYS 4301 Computational
- PHYS 4306 Senior Project (Writing Intensive)*
- PHYS 4308 Quantum Mechanics II
- PHYS 4309 Solid State
- PHYS 4312 Nuclear and Particle
- ASTR 4301 Astrophysics I
- ASTR 4302 Astrophysics II

**Required Mathematics Courses (18 hours)**

- MATH 1451 Calculus I
- MATH 1452 Calculus II
- MATH 2450 Calculus III
- PHYS 4325 -OR- MATH 3350 -OR- MATH 3354
- PHYS 4326 -OR- MATH 3351 -OR- MATH 4354

Students are strongly encouraged to take MATH 2360 (Linear Algebra) to complete a MATH minor.
## Scheduling of Physics Course Offerings

The following courses are offered every long semester and in the summer: ASTR 1400, ASTR 1401, PHYS 1408, and PHYS 2401. PHYS 2305, 2302 (beginning in Fall 2018), 3301, 3101, 3201 (beginning in Spring 2019), 3304, 3401, 3000, 4000, and 4306 are offered every long semester. PHYS 3000 may also be done in summer sessions with instructor permission.

Other courses are offered as shown in the listing below and depending on instructor availability.

**This schedule will be effective in Fall 2018.**

### Courses Offered in AY 2018-19

<table>
<thead>
<tr>
<th>FALL 2018</th>
<th>SPRING 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>2305 Computation for the Physical Sciences</td>
<td>2305 Computation for the Physical Sciences</td>
</tr>
<tr>
<td>3304 Intermediate Experimental Physics</td>
<td>3304 Intermediate Experimental Physics</td>
</tr>
<tr>
<td>3305 E&amp;M I</td>
<td>3306 E&amp;M II</td>
</tr>
<tr>
<td>3401 Optics</td>
<td>3401 Optics</td>
</tr>
<tr>
<td>4307 Quantum I</td>
<td>4301 Computational</td>
</tr>
<tr>
<td>4326 Math Methods II</td>
<td>4302 Statistical</td>
</tr>
<tr>
<td>ASTR 2401 Observational Astronomy</td>
<td>4304 Mechanics</td>
</tr>
<tr>
<td>ASTR 4302 Astrophysics II</td>
<td>4308 Quantum II</td>
</tr>
<tr>
<td></td>
<td>4312 Nuclear and Particle</td>
</tr>
<tr>
<td></td>
<td>4325 Math Methods I</td>
</tr>
<tr>
<td></td>
<td>ASTR 4301 Astrophysics I</td>
</tr>
</tbody>
</table>

### Courses Planned for Future Semesters

#### ODD FALLS

<table>
<thead>
<tr>
<th>EVEN SPRINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2305 Computation for the Physical Sciences</td>
</tr>
<tr>
<td>3304 Intermediate Experimental Physics</td>
</tr>
<tr>
<td>3305 E&amp;M I</td>
</tr>
<tr>
<td>3401 Optics</td>
</tr>
<tr>
<td>4301 Computational</td>
</tr>
<tr>
<td>4307 Quantum I</td>
</tr>
<tr>
<td>4326 Math Methods II</td>
</tr>
<tr>
<td>ASTR 2401 Observational Astronomy</td>
</tr>
<tr>
<td>ASTR 4302 Astrophysics II</td>
</tr>
</tbody>
</table>

#### EVEN FALLS

<table>
<thead>
<tr>
<th>ODD SPRINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2305 Computation for the Physical Sciences</td>
</tr>
<tr>
<td>3304 Intermediate Experimental Physics</td>
</tr>
<tr>
<td>3305 E&amp;M I</td>
</tr>
<tr>
<td>3401 Optics</td>
</tr>
<tr>
<td>4301 Computational</td>
</tr>
<tr>
<td>4307 Quantum I</td>
</tr>
<tr>
<td>4309 Solid State</td>
</tr>
<tr>
<td>4326 Math Methods II</td>
</tr>
<tr>
<td>ASTR 2401 Observational Astronomy</td>
</tr>
<tr>
<td>ASTR 4302 Astrophysics II</td>
</tr>
</tbody>
</table>

#### EVEN SPRINGS

<table>
<thead>
<tr>
<th>ODD FALLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2305 Computation for the Physical Sciences</td>
</tr>
<tr>
<td>3304 Intermediate Experimental Physics</td>
</tr>
<tr>
<td>3305 E&amp;M I</td>
</tr>
<tr>
<td>3401 Optics</td>
</tr>
<tr>
<td>4301 Computational</td>
</tr>
<tr>
<td>4307 Quantum I</td>
</tr>
<tr>
<td>4309 Solid State</td>
</tr>
<tr>
<td>4326 Math Methods II</td>
</tr>
<tr>
<td>ASTR 2401 Observational Astronomy</td>
</tr>
<tr>
<td>ASTR 4305 Radiative Processes</td>
</tr>
</tbody>
</table>
Physics Course Descriptions

1171. Physics Fieldwork (1:0:3). 1 Credit Hour. Interact with public school teachers and students to deliver a limited lesson for students. Texas Tech student will learn and implement a lesson.

1304. Physics: Basic Ideas and Methods (3:3:0) 3 Credit Hours. Intended to provide physics background to pre-engineering students. Examines basic concepts in physics. Problem-solving techniques, graphical representations, and pertinent mathematics.

1401. Physics for Nonscience Majors (4:3:2). 4 Credit Hours. Covers the basic laws and vocabulary of science using a minimum of mathematics. Partially fulfills core Life and Physical Sciences requirement.

1402. Physics of Living Matter (4:3:2). 4 Credit Hours. Covers the physics principles found in living matter and techniques useful in biomedical sciences. Not for physics majors.

1403. General Physics I (4:3:3). 4 Credit Hours. Prerequisite: MATH 1320, MATH 1550, MATH 1420, MATH 1451, or MATH 1321. Non-calculus introductory physics covering mechanics, heat, and sound, thus providing background for study in science-related areas. Partially fulfills core Life and Physical Sciences requirement.

1404. General Physics II (4:3:3). 4 Credit Hours. Prerequisite: PHYS 1403. Non-calculus introductory physics covering electricity, magnetism, light, and modern physics, thus providing background for study in science-related areas. Partially fulfills core Life and Physical Sciences requirement.

1406. Physics of Sound and Music (4:3:3). 4 Credit Hours. Sound and music, including waves, harmonics, musical instruments, voice, hearing, room acoustics, elementary music theory, classroom demonstrations, music performances, high school mathematics. Laboratory. Satisfies natural science requirement in Arts and Sciences. Partially fulfills core Life and Physical Sciences requirement.

1408. Principles of Physics I (4:3:3). 4 Credit Hours. Prerequisite: MATH 1451. Calculus-based introductory physics covering mechanics, kinematics, energy, momentum, and thermodynamics. (Honors section offered) Partially fulfills core Life and Physical Sciences requirement.

2401. Principles of Physics II (4:3:3). 4 Credit Hours. Prerequisites: PHYS 1408 and MATH 1452. Calculus-based introductory physics covering electric and magnetic fields, electromagnetic waves, and optics. (Honors section offered) Partially fulfills core Life and Physical Sciences requirement.

2305. Computation for the Physical Sciences (3:3:0). 3 Credit Hours. Prerequisites: PHYS 1408 and PHYS 2401. Introduces computational tools to solve science problems. Emphasizes interplay between technology application and practical learning.

2302. Principles of Physics III: Intermediate Classical Mechanics (3:3:0). 3 Credit Hours. Prerequisites: C or better in PHYS 1408 and MATH 1452. Special and general relativity, thermodynamics, and statistical dynamics.
3301. Principles of Physics IV: Introduction to Quantum Physics (3:3:0). 3 Credit Hours. Prerequisite: PHYS 1408 and MATH 2450. Corequisites: PHYS 3201 or PHYS 3101. Failure of classical physics in the microscopic realm, development and fundamentals of quantum theory, applications to atoms, molecules, solids, nuclei, and particles.

3101. Legacy Modern Physics Lab (1:0:1). 1 Credit Hour. Corequisite PHYS 3301. Laboratory experiments designed to illustrate the basis of quantum physics. (For students with catalog terms before Fall 2017).

3201. Modern Physics Lab and Data Analysis (2:1:1). 2 Credit Hours. Corequisite PHYS 3301. Laboratory experiments and accompanying lectures designed to illustrate the basis of quantum physics and proper techniques for data acquisition, analysis, and determination of uncertainties. (For students with catalog terms Fall 2017 and after).

3000. Undergraduate Research (V1-6). 1 to 6 Credit Hours. Prerequisite: Permission of the instructor. Individual and/or group research projects in basic or applied physics, under the guidance of a faculty member.

3304. Intermediate Physics Laboratory (3:0:6). 3 Credit Hours. Prerequisite: C or better in PHYS 3301 and PHYS 2305. Laboratory course on advanced physical principles. Experiments in atomic, molecular, solid state, and nuclear, and particle physics as well as relativity, electricity and magnetism including data acquisition and analyses. (Writing Intensive).

3305. Electricity and Magnetism I (3:3:0). 3 Credit Hours. Prerequisite: PHYS 2401 and MATH 4325 or equivalent. Electrostatics, dielectric materials, Maxwell’s equations, currents, and magnetostatics.

3306. Electricity and Magnetism II (3:3:0). 3 Credit Hours. Prerequisite: PHYS 3305 and MATH 4326 or equivalent. Magnetic properties of materials, electrodynamics, electromagnetic waves, waveguides and resonators, interaction with matter, AC circuits, radiation.

3400. Fundamentals of Physics (4:3:3). 4 Credit Hours. Prerequisites: Education majors only; preference given to EC or HDFS; instructor approval. Teaches the fundamentals of physics and strategies for teaching these fundamentals. Not open to engineering, science, or mathematics majors.

3401. Optics (4:2:4). 4 Credit Hours. Prerequisites: PHYS 1408 and PHYS 2401. Covers geometrical and physical optics, waves, reflection, scattering, polarization, interference, diffraction, modern optics, and optical instrumentation. (Writing Intensive).

4000. Independent Study (V1-4). 1 to 4 Credit Hours. Prerequisite: Approval of advisor. Study of advanced topics of current interest under direct supervision of a faculty member.

4302. **Statistical and Thermal Physics (3:3:0).** 3 Credit Hours. Prerequisites: PHYS 3301 and PHYS 4325 or equivalent. Introduction to statistical methods in physics. Formulation of thermodynamics and statistical mechanics from a unified viewpoint with applications from classical and quantum physics.

4304. **Mechanics (3:3:0).** 3 Credit Hours. Prerequisite: PHYS 1408 and PHYS 4325 or equivalent. Dynamics of particles and extended bodies, both rigid and fluid, using Newtonian mechanics and the Euler-Lagrange equations from Hamilton’s principle. Nonlinear systems and chaos with numerical modeling. Applications of the Navier Stokes equation.

4306. **Capstone Project (3).** 3 Credit Hours. Prerequisite: Senior standing in physics major. Research in a current topic in physics and astronomy with a faculty mentor culminating in an oral presentation and a written report. (Writing Intensive).

4307. **Quantum Mechanics I (3:3:0).** 3 Credit Hours. Prerequisite: C or better in PHYS 3301 and PHYS 4325 or equivalent. Introduction to fundamental concepts in quantum mechanics: probability, normalization, operators, solutions to Schrodinger equation for various potentials. Discussion of quantum mechanics in 3D, generalized uncertainty principle, angular momentum and hydrogen atom.

4308. **Quantum Mechanics II (3:3:0).** 3 Credit Hours. Prerequisite: PHYS 4307. Review of quantum mechanics, time-independent and dependent perturbation theory, variational principle, WKB approximation, the adiabatic approximation and scattering.

4309. **Solid State Physics (3:3:0).** 3 Credit Hours. Prerequisites: PHYS 3305 and knowledge of elementary quantum mechanics. The structural, thermal, electric, and magnetic properties of crystalline solids. Free electron theory of metals. Concept of energy bands and elementary semiconductor physics.

4312. **Nuclear and Particle Physics (3:3:0).** 3 Credit Hours. Prerequisite: PHYS 4307. Deals with modern nuclear physics covering such topics as nuclear structure models, radioactivity, nuclear reactions, elementary particles, nuclear conservation, forces, and symmetry.

4325. **Mathematical Methods in Physical Sciences I (3:3:0)** 3 Credit Hours. Prerequisite: C or better in MATH 2450. Vectors and coordinate systems, vector and scalar fields, ordinary differential equations, boundary-value problems and partial differential equations. (MATH 4325)

4326. **Mathematical Methods in Physical Sciences II (3:3:0)** 3 Credit Hours. Prerequisite: C or better in PHYS 4325. Continuation of PHYS 4325. Calculus of variations, an introduction to complex analysis special functions, integral transforms. (MATH 4326)

4350. **Relativity (3:3:0)** 3 Credit Hours. Prerequisites: C or better in PHYS 3305 and PHYS 4304 (may be taken concurrently). Introduction to spacetime, differential geometry, special and general relativity; with applications to black holes, cosmology, and gravitational waves.
Astronomy Course Descriptions

ASTR 1400. Solar System Astronomy (4:3:2). 4 Credit Hours. Covers the sun, planets, moons, asteroids, comets, gravitation, and formation. (Honors section offered.) Partially fulfills core Life and Physical Sciences requirement.

ASTR 1401. Stellar Astronomy (4:3:2). 4 Credit Hours. Covers stars, star formation, galaxies, and cosmology models. (Honors section offered.) Partially fulfills core Life and Physical Sciences requirement.

ASTR 2401. Observational Astronomy (4:2:2). 4 Credit Hours. Prerequisite: ASTR 1400 or 1401 or consent of instructor. Designed for anyone interested in learning the use of an optical telescope, both visually and for imaging.

ASTR 4301. Astrophysics I (3:3:0). 3 Credit Hours. Prerequisite: PHYS 3301. Introduction to the tools of astronomy, stellar properties, stellar structure, and stellar evolution.

ASTR 4302. Astrophysics II (3:3:0). 3 Credit Hours. Prerequisite: PHYS 3301. Structure, formation and evolution of galaxies; cosmology.

ASTR 4305. Radiative Processes in Astrophysics (3:3:0). 3 Credit Hours. Prerequisites: C or better in PHYS 3305 and PHYS 4307. A survey of the physical processes related to the production and propagation of radiation in astrophysical phenomena, including thermal and non-thermal radiation, and atomic transitions.
Faculty Members


Optical Physics.

Atomic, Molecular & Optical Physics


Physics.

