DEPARTMENT OF PHYSICS & ASTRONOMY

at

THE UNIVERSITY OF MISSOURI-ST. LOUIS

Undergraduate Student Handbook

2016-2017
Department of Physics & Astronomy
University of Missouri-St. Louis
One University Boulevard
St. Louis, MO 63121
314-516-5931
http://www.umsl.edu/~physics
Welcome to the Department of Physics and Astronomy at the University of Missouri-St. Louis. This brief student advising handbook is designed to answer the most commonly asked questions concerning study in the program and related matters.

You are encouraged to read this comprehensive guide carefully. Also be sure to check the Department bulletin boards regularly for important announcements and consult our home page on the World Wide Web (http://www.umsl.edu/~physics/).

Any further inquiries can be directed to:

The Department of Physics and Astronomy
503 Benton Hall
University of Missouri-St. Louis
314-516-5931

I. THE FACULTY............................................................................................ 3
II. ADMISSIONS AND REGULATIONS.......................................................... 7
III. THE PHYSICS DEGREE PROGRAMS...................................................... 8
IV. TENTATIVE SCHEDULES.......................................................................... 14
V. TENTATIVE THREE-YEAR TEACHING PLAN.......................................... 16
VI. B.S. IN EDUCATION WITH PHYSICS EMPHASIS................................. 17
VII. DESCRIPTIONS OF COURSES............................................................... 18
VIII. SCHOLARSHIPS, AWARDS, AND FINANCIAL SUPPORT.................... 26
IX. THE PHYSICS CLUB................................................................................ 28
X. TRANSFER CREDITS............................................................................... 29
XI. CAREER OUTLOOK.................................................................................. 30
I. THE FACULTY

Sonya Bahar, Professor  
Ph.D, University of Rochester  
_Biophysics, Nonlinear Dynamics, Neuroscience_  
Dr. Bahar applies the physics of nonlinear dynamics and complex systems to the study of collective biological phenomena. Her most recent work involves the development of models for the process of speciation in biological evolution. She is investigating how (1) parameters such as mutation rate affect the dynamics of speciation, (2) how evolutionary processes can be described with the statistical physics of nonequilibrium phase transitions, and (3) how physics-based approaches can be used to gain insights into the problem of multi-level selection. Other research projects in include computational and experimental studies of neural synchronization in pathological processes such as epilepsy. Her group has used voltage-sensitive dyes in order to investigate neural synchronization during focal seizures in the rat neocortex. Other projects involve the use of nonlinear techniques for the investigation of human neural processes, such as synchronization between eye and target movement in mild traumatic brain injured (mTBI) patients.

Bernard J. Feldman, Professor  
Ph.D., Harvard University  
_Physics Education_  

Michael Fix, Teaching Professor  
Masters Degree, Washington University  
_Paleontology and Stratigraphy_  
Professor Fix does his research on the late Cretaceous age Chronister Dinosaur Site in Southeastern Missouri, the only known dinosaur site in the entire state. He is project geologist for the Missouri Ozark Dinosaur Project that is affiliated with the Bollinger County Museum of Natural History in Marble Hill, Mo. The project has been conducting an excavation of the site since 1999 inside a protective 20 by 36 foot greenhouse that has a 60 square meter hanging grid for detailed mapping of fossil finds. Prof. Fix is responsible for the mapping and other record keeping as well as helping with excavation. He also prepares most of the specimens after they have been removed. This includes a partial disarticulated skeleton of a juvenile hadrosaur (duckbilled dinosaur) that is on public display at the museum. Fragments of the skull of the same specimen will help to further define the affinities of this dinosaur. The dinosaurs that have been identified from the site so far are the previously mentioned hadrosaur, _Hypsibema missouriense_ - the official Missouri state dinosaur, as well as a relative of _T-rex_, and a relative of _Velociraptor_. The site also yields fossils of crocodylians, fish, turtles, lizards and amphibians. Dinosaur sites are relatively rare in the eastern U.S., and fewer still are sites that yield as many fossils, and so this site is very important in documenting the biogeographic distribution of dinosaur species of the late Cretaceous period as well as evolutionary patterns. Prof Fix is jointly working with Dr. David Parris of the New Jersey State Museum and Dr. Barbara Grandstaff of the University of Pennsylvania on a paper on the site that is to be submitted to the Journal of Vertebrate Paleontology.
Ricardo A. Flores, Professor
Ph.D., University of California-Santa Cruz
Particle Physics/Astrophysical Cosmology
Dr. Flores' work in astrophysics concentrates on understanding the properties and formation of galaxies and clusters of galaxies, and how they test cosmological theories. His work in particle physics is mostly on searches for supersymmetric dark matter and the structure of nucleons; he is also interested in neutrino oscillations.

Philip B Fraundorf, Associate Professor
Ph.D., Washington University
Materials Physics & Astronomy, Nanoscale Characterization, Modernizing Content
Research highlights and developing stories, listed at http://www.umsl.edu/~fraundor/hilights.html, involve nanoscale structures in electronic and extraterrestrial materials, atomic resolution electron and scanning probe microscopy, computer simulations, and development of emergent-content course material involving nanoscale detective challenges as well as energy and information in everyday life. The first two items involve a triple/bi-story building designed for regional outreach, with Missouri’s only atomic resolution transmission electron microscope along with research grade atomic force and scanning electron microscopes. The increased relevance of nanoscale detective work in fields of electronic and extraterrestrial materials, medicine, catalysis, crime scene investigation and metals has brought in cross-disciplinary collaborations, helped start a statewide nano-alliance, and put graduates into jobs with employers MEMC Electronic Materials (St. Peters MO), Seagate (Minneapolis), Martin-Marietta (New Orleans), Mitsubishi Silicon America (Portland), and most recently Motorola’s Digital DNA Lab (Mesa AZ).

Erika Gibb, Professor and Chairperson
Ph.D., Rensselaer Polytechnic Institute
Observational Astrophysics/Astrobiology
Dr. Gibb is an astrochemist, studying chemistry in star formation regions and comets. One of the most exciting areas of astrobiological research is the search for organic molecules of prebiotic importance in disks and envelopes of gas and dust around low mass young stars that are thought to be similar to the young solar system. She uses infrared spectroscopy to detect molecules and infer the quantity, temperature, and location of each molecule. The observations are usually performed at major telescopes like the 10-meter Keck Observatory and the 3-meter Infrared Telescope Facility on Mauna Kea, HI or the 8-meter Gemini South Observatory in Chile. She also collaborates with a research group at NASA Goddard Space Flight center to measure abundances of those same molecules in comets, which are thought to have been a source of much of the early Earth’s reserve of organics and water. In this way, she hopes to track the organic chemistry through the star and planet formation process and to be able to infer the role that comets may have played on delivery of organics and water necessary for life on Earth.

Thomas F. George, Professor and Chancellor
Ph.D., Yale University
Lasers, Materials Physics
Dr George is involved in theoretical research in several areas of laser/materials physics. One area involves molecular clusters, where excitation processes in fullerenes by ultra fast laser pulses are being investigated theoretically by numerically solving the Liouville equation for electron density matrices. Comparisons are then carried out with experiments in regard to the control of vibrational excitations. Another area is nonlinear optical processes, where a theory of quantum control of short-wavelength
sum-frequency generation, which employs continuum states, has been developed. Nonlinear interference processes in a multi-level ladder-type quantum system are being considered, along with the coupling of several strong laser fields with adjacent bound-bound (discrete) and bound-free (continuous) transitions in the continuous wave regime, accounting for relaxation of coherence. Also, quantum switching and amplification without inversion controlled by two optical fields are being examined in connection with (1) solids doped by rare earths and (2) and atomic and molecular vapors. A third area involves ultra fast laser-driven materials processing, where femtosecond laser pulses are used in a theoretical analysis of micro processing of metals, semiconductors and dielectrics. Here, a two-temperature model (energy coupling between electronic and phonon subsystems), the role of Dember effects, and ballistic transport are being considered. Step melting of crystalline and amorphous lead foils due to irradiation by ultraviolet laser pulses are being examined experimentally by optical microscopy-densitometry and atomic force microscopy methods. Finally, as a side project just for fun, Newtonian mechanics is being applied to help resolve the controversy of two opposite theories explaining the origin of vertebrate flight: (1) running and leaping into flight (“ground-up theory”) and (2) gliding to flight (“tree-down theory”).

Bob L. Henson, Professor
Ph.D., Washington University
Mathematical and Statistical Physics
Dr. Henson's primary research efforts now are mostly theoretical, but at a reduced level of activity. Currently, his primary interests are in atmospheric physics and the fundamental foundations of statistical mechanics. However, Dr. Henson’s main scholarly activity now is writing a text on the topic of atmospheric physics at the senior-graduate level. He is approaching this by writing up and expanding his class notes for Physics 4354 (Atmospheric Physics), which he has taught several times over the past thirty years.

David Horne, Assistant Teaching Professor
Ph.D., University of Toledo
Astrophysics/Planetary Science-Atmospheres
Dr. Horne has a range of research experience utilizing infrared astronomical observations. This includes observations of the polar dust storms of Mars and the dynamics/chemistry of circumstellar disks. Through his interest in atmospheric dynamics, Dr. Horne has recently returned to the idea of observing the effects of 2-D vortex interactions in fluids. He is currently developing practical apparatus to demonstrate the interaction of 2-D vortices in a laboratory setting.

Eric Majzoub, Professor
Ph.D., Washington University
Materials and Computational Physics
Dr. Majzoub is the Associate Director of the Center for Nanoscience, and holds a joint appointment in the Department of Chemistry and Biochemistry. The research in Dr. Majzoub’s group is both computational and experimental. Dr. Majzoub uses state-of-the-art computational tools including ab initio quantum mechanical methods, stochastic methods including molecular dynamics and Monte Carlo simulations, and other general computational methods used in condensed matter and solid-state physics. Our group uses these methods to investigate novel materials for energy storage and conversion, as well as sensing technologies. Our group also performs experimental research using the tools of condensed matter physics and inorganic chemistry for the synthesis and characterization of bulk and nano-crystalline materials. Current research interests: hydrogen storage in complex hydrides; Li-ion, H-ion, and other battery chemistries; nanoporous frameworks for enhancing kinetics and controlling reaction pathways in energy storage materials; Monte Carlo techniques for crystal structure prediction; crystal
structure determination and characterization; lattice vibrational properties of molecular crystals; nanoporous materials.

**Bruce A. Wilking, Professor and Associate Chairperson**  
Ph.D., University of Arizona  
*Observational Astrophysics*

The earliest stages in the formation of stars are hidden from view by microscopic dust. Since infrared and radio wavelengths of light are relatively unaffected by this dust, Dr. Wilking makes astronomical observations at these wavelengths to study the formation of low mass stars. Using infrared imaging and spectroscopy, Dr. Wilking studies the ages and masses of young stars in nearby clouds to reconstruct the star-forming history of the region. Using radio interferometry, observations of water masers are used to trace the dynamics and distribution of dense gas surrounding the youngest stars. Undergraduate research stipends in astrophysics are available for the summer and academic year through the NASA/Missouri Space Grant Consortium.
II. ADMISSIONS AND REGULATIONS

Admission
Students must meet the general requirements for admission to the University, which are stated in the BULLETIN of the University of Missouri-St. Louis.

Students transferring from other colleges and universities must submit the following information to the UM-St. Louis Director of Admissions:
(i) Undergraduate Application for Admission;
(ii) High School Transcript;
(iii) Official Transcripts from all colleges/universities attended.

Please check with the Department for detailed information concerning transferring credit hours from local community colleges.

Registration and Cancellation
Each semester, you will receive information from the Registrar about how to register for classes through MyView. Every Physics Major will have an “advising hold” on their registration each semester. Once you have talked with Dr. Sonya Bahar, Undergraduate Advisor, about the courses you plan to take, she will have the advising hold lifted and then you can register. Dr. Bahar’s office is 503e Benton Hall, telephone number is 314-516-7150 and email address is bahars@umsl.edu. Ideally, you should contact her at the earliest convenient date before each semester to help the Department track projected course enrollment and to make sure you aren’t missing any of the courses you need as prerequisites.

Students who have enrolled and paid their fees but do not wish to attend the University may cancel their registration at the Office of the Registrar according to university policy.

Auditor
A student may enroll as an auditor in any course with the prior consent of the instructor and dean of the school or college in which the auditor is registered. Auditors are charged full fees and receive no academic credit.

Grading System
The grading system available to all faculty in all schools, colleges, and other parallel units is

\[
\begin{array}{cccc}
A &=& 4.0 & A- = 3.7 & B+ &=& 3.3 & B &=& 3.0 \\
B- &=& 2.7 & C+ &=& 2.3 & C &=& 2.0 & C- &=& 1.7 \\
D+ &=& 1.3 & D &=& 1.0 & D- &=& 0.7 & F &=& 0.0 \\
\end{array}
\]
III. THE PHYSICS DEGREE PROGRAMS

The Program
The study of physics is an attempt to understand the fundamental nature of the forces and particles and the resultant states of matter that make up the physical world. The Department of Physics and Astronomy at UM-St. Louis is devoted to providing undergraduates with a broad-based education in the fundamental concepts of physics and with the experimental and theoretical skills essential to practicing scientists. Outside the classroom, research opportunities for undergraduates are available in many fields. Undergraduate education in physics prepares students for both graduate study and professional careers.

The Department offers course work leading to a B.A. in Physics, a B.S. in Physics, and in cooperation with the School of Education, a B.A. in Physics with teacher certification and a B.S. in Education with an emphasis in Physics.

General Education Requirements:
Majors must complete the university and college general education requirements. Any of the following courses may be used to satisfy the physical science requirement:

- Astronomy: 1001, 1001A, 1011, 1012, 1121, 1050, 1051.
- Atmospheric Science: 1001, 1001A.
- Geology: 1001, 1002, 1001A, 1002A.
- Physics: 1001, 1011, 1011A, 1012, 1012A, 2111, 2112.

Degree Requirements for Major in Physics

All physics majors, who are transfer students, must complete Physics 1099, Windows on Physics. First time freshmen must take INTDSC 1003. All physics majors in all programs must complete the physics core curriculum. In addition to the core courses, each individual program has its own specific requirements. Required Physics, Mathematics, Chemistry, Biology, Optometry and Computer Science courses for a major or minor in physics may not be taken on a satisfactory/unsatisfactory grading basis.

*** Core Curriculum The following physics courses are required:

- 2111, Physics: Mechanics and Heat
- 2112, Physics: Electricity, Magnetism, and Optics
- 3200, Mathematical Methods of Theoretical Physics
- 3221, Mechanics
- 3223, Electricity and Magnetism
- 3231, Introduction to Modern Physics I

Also required are:

- Math 1800, Analytic Geometry and Calculus I
- Math 1900, Analytic Geometry and Calculus II
- Math 2000, Analytic Geometry and Calculus III
- Math 2020, Introduction to Differential Equations
- Chem 1111, Introductory Chemistry I or equivalent
- Computer Science 1250, Introduction to Computer Science

Note: Students are urged to begin the calculus sequence (Math 1800, Math 1900 and Math 2000) as soon as possible to avoid delays in graduation.
Students with experience in digital computer programming may be excused from Computer Science 1250.

*** Bachelor of Arts in Physics ***
The B.A. program is tailored to students wishing to preserve the option for specialization in graduate school without sacrificing the advantages of a liberal arts education. The Department of Physics and Astronomy will accept the three-course sequence in American Sign Language as satisfying the foreign language requirement for this degree. In addition to the core curriculum, including the foreign language requirement, at least three physics electives at the 3000 or 4000 level must be completed. It is recommended that at least one of these three electives includes Astronomy 4322, Physics 4311 or Physics 4347 for the required capstone course. At least 31 hours of physics courses, but no more than 45 hours, are required.

*** Bachelor of Science in Physics ***
The B.S. degree provides students with six options: general physics, astrophysics, engineering physics, medical physics, optical biophysics.

1. *General Physics Option*
   This option may be elected by students desiring a greater concentration in physics and mathematics and is recommended for students wishing to enter graduate study in physics. At least 50 hours are required. In addition to the core curriculum, the following physics courses are required:

   Physics
   4310, Modern Electronics
   4311, Advanced Physics Laboratory I
   4323, Modern Optics
   4331, Introduction to Quantum Mechanics
   4341, Thermal and Statistical Physics
   4350, Computational Physics (or a 4000 level mathematics course)
   and three electives at or above the 4000 level in physics or astronomy.

   Astronomy
   1050, Introduction to Astronomy I or 1051, Introduction to Astronomy II

   Also required are:
   Mathematics
   MATH 2450, Elementary Linear Algebra
   and one elective in mathematics at or above the 3000 level, or in computer science at or above the 2000 level.

   Chemistry
   1121, Introductory Chemistry II, or equivalent

2. *Astrophysics Option*
   This option may be elected by students who have interests in the aerospace science or anticipate graduate studies in astrophysics. At least 48 hours must be taken. In addition to the core curriculum, the following physics courses are required:
Physics
4323, Modern Optics
4331, Introduction to Quantum Mechanics
4341, Thermal and Statistical Physics
4350, Computational Physics

Astronomy
1050, Introduction to Astronomy I
1051, Introduction to Astronomy II
4301, Astrophysics
4322, Observational Astronomy

And one physics elective at or above the 4000 level. With consent of the astronomy adviser, there may be substitution of Astronomy 1001, 1011, or 1012 for 1050 or 1051.

Also required:
Math 2450, Elementary Linear Algebra

3. Engineering Physics Option
Students interested in careers in the research and development field of industry should consider this option. This program exposes the student to a basic engineering curriculum, as well as to areas of physics with industrial applications, such as electronics, modern optics, and linear analysis. At least 49 hours, but no more than 51, are required. In addition to the core curriculum, the following courses are required:

Joint Engineering
2310, Statics
2320, Dynamics

Joint Electrical Engineering
2300, Introduction to Electrical Networks

Physics
4310, Modern Electronics
4311, Advanced Physics Laboratory I
4323, Modern Optics
4331, Introduction to Quantum Mechanics
4341, Thermal and Statistical Physics

Math
1320, Applied Statistics I and 2450, Elementary Linear Algebra

Also required is one elective in math at or above the 3000 level, or in computer science at or above the 2000 level.
4. Biophysics Option
This option is designed for students who are interested in careers in various medical fields or biophysics. This option provides a strong preparation in physics, mathematics, chemistry, and biology for students who intend to apply for admission to medical school, to an interdisciplinary graduate program such as biophysics or bioengineering, or to pursue an interdisciplinary scientific career. At least 41 hours of physics and biology combined, but no more than 51, are required. In addition to the physics core curriculum, the following physics and biology courses are required:

Physics
4310, Modern Electronics
4347, Introduction to Biophysics
and two additional physics electives at the 4000 level.

Biology
1811, Introductory Biology I, From Molecules to Organisms
1821, Introductory Biology II, Organisms and the Environment

Also required are:

Chemistry
1121, Introductory Chemistry II
2612, Organic Chemistry I
2622, Organic Chemistry II
2633, Organic Chemistry Laboratory

5. Optical Biophysics Option
This program is designed for students wanting to obtain a strong biophysics emphasis that will also prepare them for the optometry program at UM-St. Louis. This 3+4 program allows students to complete their B.S. in physics and Doctor of Optometry degrees in seven years. Students can complete their B.S. in physics degree in their fourth year while starting coursework in the School of Optometry. A total of 51 hours in physics, biology, and optometry courses are required. In addition to the physics core curriculum, the following courses are required:

Physics
4341, Thermal and Statistical Physics

Biology
1811, Introduction to Biology I
1821, Introduction to Biology II
2482, Microbiology
2483, Microbiology Laboratory

Optometry (fourth year only)
8020, Geometric Optics
8060, Biochemistry
8120, Ocular Optics
8140, Physical Optics and Photometry Lab (Note: Optometry is no longer offering this class; any students needing this class should consult with the Physics Department and Optometry Program regarding a replacement course.)

Also required are:

Chemistry
1121, Introductory Chemistry II
2612, Structural Organic Chemistry
2622, Organic Reactions
2633, Techniques of Organic Chemistry

Psychology
1003, General Psychology and one additional course

Statistics
Math 1320, Applied Statistics or
Psychology 2201, Psychological Statistics

Note: Upon declaring physics as a major and selecting this option, students should seek an initial interview with the Director of Student Affairs and the Pre-Optometry Advisor in the UM-St. Louis School of Optometry to ensure that all prerequisites for the School of Optometry will be completed. A similar review is recommended at the beginning of the Spring Semester of the second year. In August following the completion of their second year of this program, students may apply formally to the UM-St. Louis School of Optometry and arrange to take the Optometry Admissions Test (OAT) in October of their third year. The applicant will be invited for a formal interview for acceptance into the School of Optometry professional program following receipt of a completed application in the Fall Semester of the candidate's third year. Following the formal interview with the School of Optometry at the beginning of the third year, students with a 3.0 or better grade point average in the science prerequisites for optometry and a score of 310 or better on the OAT exam may be accepted into the School of Optometry.

Physics Education Programs

Bachelor of Science in Education with Emphasis in Physics
This program is designed for students wishing to teach physics in secondary schools and give a firm foundation in the history, philosophy and principles of physics. Students are typically expected to fulfill the School of Education's general education requirements. For details, see Section VI and contact the College of Education advising office at 314-516-5937.

Master’s Level Teaching Certification for Physics Majors
Physics majors who complete a B.A. or B.S. degree in Physics may obtain teaching certification through the Graduate School and College of Education’s Teach in 12 program. Contact the advising office (OASIS) 314-516-5937 in the College of Education for program requirements, or visit the Teach in 12 website: http://coe.umsl.edu/advising/t12/.
**Minor in Physics**

Students may complete a minor in physics with the flexibility of emphasis on classical physics, modern physics, or a combination of the two areas. The following physics courses are required:

- **1099**, Windows on Physics or **INTDSC 1003**, Freshman Success Seminar
- **2111**, Mechanics and Heat
- **2112**, Electricity, Magnetism, and Optics
- **3200**, Mathematical Methods of Theoretical Physics
- and **two** additional emphasis courses chosen from the following physics courses:
  - **3221**, Mechanics
  - **3223**, Electricity and Magnetism
  - **3231**, Introduction to Modern Physics
  - **4310**, Modern Electronics

A GPA of at least 2.0 is required in courses presented for a minor. It is required that a student completes a minimum of 6 hours of graded work in 2000 level or above courses on the UM-St. Louis campus.
### IV. TENTATIVE SCHEDULES

NOTE: The suggested sequences of courses below have been designed with prerequisites and current offerings in mind in order that students may be able to graduate in a minimum of four years. However, because the Department of Physics & Astronomy has no control over course offerings outside the department, it may not always be possible for each individual student to graduate in four years. Also, future offerings within the department will be dependent upon having sufficient faculty and monetary resources.

Suggested Physics/Math Sequence of Courses for Bachelor of Science with **General Physics Option**:

<table>
<thead>
<tr>
<th>Beginning</th>
<th>Spring 1</th>
<th>Fall 2</th>
<th>Spring 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 1</td>
<td>Math 1800</td>
<td>Phys 2111</td>
<td>Phys 2112</td>
</tr>
<tr>
<td>Phys 1099</td>
<td>Chem 1121</td>
<td>Math 1900</td>
<td>Math 2000</td>
</tr>
<tr>
<td>Math 1030</td>
<td>CSci 1250</td>
<td>Math 2450</td>
<td></td>
</tr>
<tr>
<td>Math 1035</td>
<td>Option 1: Ast 1051</td>
<td>Option 2: CSci 2xxx or Math 3xxx</td>
<td></td>
</tr>
<tr>
<td>Chem 1111</td>
<td>Ast 1051</td>
<td>Ast 1050</td>
<td></td>
</tr>
</tbody>
</table>

Suggested Physics/Astronomy/Math Sequence of Courses for Bachelor of Science with **Astrophysics Option**:

<table>
<thead>
<tr>
<th>Beginning</th>
<th>Spring 1</th>
<th>Fall 2</th>
<th>Spring 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 1</td>
<td>Math 1800</td>
<td>Phys 2111</td>
<td>Phys 2112</td>
</tr>
<tr>
<td>Phys 1099</td>
<td>Ast 1051</td>
<td>Math 1900</td>
<td>Math 2000</td>
</tr>
<tr>
<td>Math 1030</td>
<td>CSci 1250</td>
<td>Math 2450</td>
<td></td>
</tr>
<tr>
<td>Math 1035</td>
<td>Ast 1050</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chem 1111</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Advanced</th>
<th>Spring 3</th>
<th>Fall 4</th>
<th>Spring 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 3</td>
<td>Phys 3221</td>
<td>Phys 4331</td>
<td>Phys 4323</td>
</tr>
<tr>
<td>Phys 3200</td>
<td>Phys 3223</td>
<td>Phys 4310</td>
<td>Phys 4311</td>
</tr>
<tr>
<td>Phys 3231</td>
<td>Phys 4341</td>
<td>Phys 43xx</td>
<td>Phys 43xx</td>
</tr>
<tr>
<td>Math 2020</td>
<td>Phys 43xx</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Option 1: Ast 4301 or Ast 4322</td>
<td>Option 2: Ast 4301 or Ast 4322</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ast 3222</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE 2**: Students should take the Option 1 or the Option 2 sequence for Ast 4322 and Ast 4301 in their junior and senior years.
Suggested Physics / Math / Engineering Sequence of Courses for Bachelor of Science with **Engineering Physics Option**:  

**Beginning:**  
<table>
<thead>
<tr>
<th>Fall 1</th>
<th>Spring 1</th>
<th>Fall 2</th>
<th>Spring 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phys 1099</td>
<td>Math 1800</td>
<td>Phys 2111</td>
<td>Phys 2112</td>
</tr>
<tr>
<td>Math 1030</td>
<td>Math 1900</td>
<td>Math 2000</td>
<td></td>
</tr>
<tr>
<td>Math 1035</td>
<td>CSci 1250</td>
<td>Engr 2310</td>
<td></td>
</tr>
<tr>
<td>Chem 1111</td>
<td>Math 1320</td>
<td>Math 2450</td>
<td></td>
</tr>
</tbody>
</table>

**Advanced:**  
<table>
<thead>
<tr>
<th>Fall 3</th>
<th>Spring 3</th>
<th>Fall 4</th>
<th>Spring 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phys 3200</td>
<td>Phys 3221</td>
<td>Phys 4331</td>
<td>Phys 4323</td>
</tr>
<tr>
<td>Phys 3231</td>
<td>Phys 3223</td>
<td>Phys 4310</td>
<td>Phys 4311</td>
</tr>
<tr>
<td>Math 2020</td>
<td>Phys 4341</td>
<td>CSci 2xxx or</td>
<td></td>
</tr>
<tr>
<td>Engr 2320</td>
<td>JEE 2300</td>
<td>Math 3xxx</td>
<td></td>
</tr>
</tbody>
</table>

Suggested Physics/Math/Chemistry/Biology Sequence of Courses for Bachelor of Science with **Biophysics Option****:  

**Beginning:**  
<table>
<thead>
<tr>
<th>Fall 1</th>
<th>Spring 1</th>
<th>Fall 2</th>
<th>Spring 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phys 1099</td>
<td>Math 1800</td>
<td>Phys 2111</td>
<td>Phys 2112</td>
</tr>
<tr>
<td>Math 1030</td>
<td>Chem 1121</td>
<td>Math 1900</td>
<td>Math 2000</td>
</tr>
<tr>
<td>Math 1035</td>
<td>Ast 1050 or 1051</td>
<td>CSci 1250</td>
<td>Math 2450</td>
</tr>
<tr>
<td>Chem 1111</td>
<td>Biol 1811</td>
<td>Biol 1821</td>
<td>Chem 2612</td>
</tr>
</tbody>
</table>

**Advanced:**  
<table>
<thead>
<tr>
<th>Fall 3</th>
<th>Spring 3</th>
<th>Fall 4</th>
<th>Spring 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phys 3200</td>
<td>Phys 3221</td>
<td>Phys 4331*</td>
<td>Phys 4347</td>
</tr>
<tr>
<td>Phys 3231</td>
<td>Phys 3223</td>
<td>Phys 4310</td>
<td></td>
</tr>
<tr>
<td>Math 2020</td>
<td>Phys 4341*</td>
<td>Biol 4713</td>
<td></td>
</tr>
<tr>
<td>Bio/Chem 4712</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Recommended but not required. Students must take two additional courses at the 4000 level; these starred courses are recommended options to fulfill this requirement.

**This option was formerly called the Medical Physics Option. The name change more accurately reflects the broad scientific background the degree provides, and is pending approval by the Missouri Coordinating Board of Higher Education.
V. TENTATIVE THREE-YEAR TEACHING PLAN

<table>
<thead>
<tr>
<th>COURSE</th>
<th>FS-16</th>
<th>SP-17</th>
<th>FS-17</th>
<th>SP-18</th>
<th>FS-18</th>
<th>SP-19</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS1001</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS1001A</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1001</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1001A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1011</td>
<td>I</td>
<td>D</td>
<td>I</td>
<td>D</td>
<td>I</td>
<td>D</td>
</tr>
<tr>
<td>A1012</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1050</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1051</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A4301</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A4322</td>
<td></td>
<td></td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G1001</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>G1001A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>G1002</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>G1002A</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>G1053</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1001</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>P1011</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>P1011A</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>P1012</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>P1012A</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>P2111</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>P2112</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>P3200</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3221</td>
<td>E</td>
<td>D</td>
<td>D</td>
<td>E</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3223</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3231</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P3281</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>P3390</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>P4305</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4306</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4310</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4311</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4323</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4331</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4341</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4350</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4351</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4353</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4370</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P4381</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td></td>
</tr>
<tr>
<td>P5345</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5357</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5370</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5402</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P5403</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

CODE: AS=Atmospheric Science; A=Astronomy; P=Physics; G=Geology; D=Day; E=Evening; I=Internet Course; FS=Fall Semester; SP=Spring Semester
VI. B.S. IN EDUCATION WITH PHYSICS EMPHASIS THROUGH THE COLLEGE OF EDUCATION

The curriculum described below is revised from the curriculum used in recent years, and is expected to be approved soon by the Missouri Department of Elementary and Secondary Education. Contact the advising office (OASIS) 314-516-5937 in the College of Education to verify coursework.

<table>
<thead>
<tr>
<th>Physics Core:</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSCS 2111 Mechanics and Heat</td>
<td>5</td>
</tr>
<tr>
<td>PHYSCS 2112 Electricity, Mag. &amp; Optics</td>
<td>5</td>
</tr>
<tr>
<td>PHYSCS 3200 Mathematical Methods</td>
<td>3</td>
</tr>
<tr>
<td>PHYSCS 3231 Modern Physics</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS 4347 Intro to Biophysics</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total Physics Core</strong></td>
<td><strong>20</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Associated Science Area:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1111 Intro Chemistry I</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 1831 From Molecules to Organisms</td>
<td>5</td>
</tr>
<tr>
<td>BIOL 1821 or 1202 or 2102 or CHEM 1011 (Must take 1821 for unified option)</td>
<td>3-5</td>
</tr>
<tr>
<td>GEOL 1001 or 1001A General Geology or ASTRON 1011</td>
<td>3-4</td>
</tr>
<tr>
<td>PHIL 3380 Philosophy of Science</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total A.S. Area</strong></td>
<td><strong>19-22</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Math Area:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1030 College Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 1035 Trigonometry</td>
<td>2</td>
</tr>
<tr>
<td>MATH 1800 Calculus I</td>
<td>5</td>
</tr>
<tr>
<td>MATH 1900 Calculus II</td>
<td>5</td>
</tr>
<tr>
<td>MATH 2000 Calculus III</td>
<td>5</td>
</tr>
<tr>
<td>MATH 2020 Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Math Area</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

| Total Credits for Physics Certification            | 62-65*  |

<table>
<thead>
<tr>
<th>Unified Science Option (Additional Courses)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ATM SCI 1001/1001A Elem. Meteorology</td>
<td>3-4</td>
</tr>
<tr>
<td>CHEM 1011 Environmental Chemistry (or equivalent env. sci. course)</td>
<td>3</td>
</tr>
<tr>
<td>PHYSCS 4341 Thermal &amp; Statistical Physics</td>
<td>3</td>
</tr>
<tr>
<td>PHYSCS 4331 Quantum Mechanics</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Additional Unified</strong></td>
<td><strong>12-13</strong></td>
</tr>
</tbody>
</table>

| Total Proposed Physics Unified**                   | 76-78*  |

*12 credit hours overlap with Gen Ed requirements (3 math proficiency, 9 science/math).
*Does not include Education coursework or other Gen Eds.
**Unified option enables teachers to teach physics plus introductory biology and chemistry.

For students majoring in Physics (or other STEM fields), there is also the option of obtaining Master’s Level teaching certification via the Graduate School and College of Education’s Teach in 12 program. Contact the advising office (OASIS) 314-516-5937 in the College of Education or visit the Teach in 12 website: [http://coe.umsl.edu/advising/t12/](http://coe.umsl.edu/advising/t12/).

For questions regarding pathways to STEM teaching certification please contact Nicolle von der Heyde (We Teach MO) at vonderheyden@umsl.edu, or Dr. Chuck Granger at grangerch@umsl.edu.
VII. DESCRIPTION OF COURSES

Prerequisites may be waived by consent of the instructor.

ASTRONOMY

1001 Cosmic Evolution/Introductory Astronomy (4)
Overview of astronomy, from the planets to the Big Bang. Topics include the celestial motions, planets and the formation of the solar system, stars and stellar evolution, galaxies, and cosmology. Students will be introduced to the latest discoveries and how they affect our understanding of the universe. The format is three classroom hours and one 2-hour laboratory session per week to enhance lecture material.

1001A Cosmic Evolution/Introductory Astronomy (3)
Same as ASTRON 1001 without the laboratory.

1011 Planets and Life in the Universe (3)
Man's concept of the solar system from Stonehenge to Einstein; geology and meteorology of the planets of our solar system, with particular attention to results from the space program; exobiology-study of the possibilities of life on other worlds and the best method of communicating with it. Three lecture hours per week.

1012 The Violent Universe and the New Astronomy (3)
A nontechnical course focusing on recent results which larger telescopes and the space program have made available. Pulsars, x-ray stars, and black holes; radio astronomy, our galaxy, and interstellar molecules; exploding galaxies and quasars; origin of the expanding universe. Three lecture hours and one observing session per week.

1050 Introduction to Astronomy I (3)
Prerequisites: Mathematics 1030 and 1035. A survey of the history of astronomy from the ancient times to present. Theories for the formation and evolution of the solar system. The general features of the solar system and planetary motions are discussed. The physical concept of gravity is presented. The detailed properties of the planets, comets, and asteroids are reviewed, concentrating on recent results from space missions. Three classroom hours per week.

1051 Introduction to Astronomy II (3)
Prerequisites: Mathematics 1030 and 1035. A survey of astronomy beyond the solar system. Topics include stars and stellar evolution, neutron stars, and black holes. The physical concept of light and the design of telescopes is discussed in detail. The structure of the Milky Way Galaxy and the large scale structure of the universe are explored. Dark matter, quasars, and active galactic nuclei are discussed in the context of theories for the formation and evolution of the universe. Course does not need to be taken in sequence with Astronomy 1050. Three classroom hours per week.

1121 The Search for Extraterrestrial Life (3)
Prerequisite: Astron 1001 or 1011. Are we alone? The possibility of life in the universe in addition to our own will be explored. Our discussion of the chances for extraterrestrial life will be built around the current theories of chemical, biological, and cultural evolution, which have led to our own technological civilization on Earth. Strategies for communication with extraterrestrial intelligence will be discussed.
4301 Astrophysics (3)
Prerequisite: Physics 3231 or consent of instructor. A moderately technical instruction to astrophysics. Topics will include: physics of stellar interiors and atmospheres; interpretation of stellar spectra; stellar evolution; radio astronomy; and cosmology.

4322 Observational Astronomy (4)
Prerequisites: ASTRON 1050, ASTRON 1051, and PHYSICS 3231 or consent of instructor. Tools of the astronomer: telescopes, spectroscopy, photoelectric photometry. Students will work on a number of projects which will enable them to develop expertise in obtaining, reducing, and analyzing astronomical observations. Student night observing will be an important part of the course. This course is primarily for persons who are astronomy or physics majors or who have some equivalent astronomical background.

ATMOSPHERIC SCIENCE

1001 Elementary Meteorology (4)
Prerequisite: Math 1020 or equivalent. An elementary course covering atmospheric phenomena, weather, and climate. Topics included are temperature, pressure, and moisture distributions in the atmosphere and dynamical effects such as radiation, stability, storms, and general circulation. Four classroom hours per week with one hour being a learning enhancement session to include demonstrations and exercises on problems solving.

1001A Elementary Meteorology (3)
Same as Atmospheric Science 1001 without the learning enhancement session.

GEOLOGY

1001 General Geology (4)
Earth materials and processes, including geological aspects of the resource/energy problem. Laboratory involves identification of common rocks and minerals.

1001A General Geology (3)
Same as GEOL 1001 without the laboratory.

1002 Historical Geology (4)
Prerequisite: Geol 1001. Study of changes in geography, climate and life through geological time; origin of continents, ocean basins, and mountains in light of continental drift. Laboratory primarily involves description and identification of fossils.

1002A Geology (3)
Same as GEOL 1002 without the laboratory.

1053 Oceanography (3)
The atmospheric and ocean circulations; the chemistry and geology of the deep sea; and their effects on the distribution of marine organisms.
PHYSICS

1001 How Things Work (3)
Provides a practical introduction to understanding common life experiences by using physical intuition and basic ideas of physics. Powerful scientific principles are demonstrated through topics ranging from airplane wings to compact disk players, from lightning strikes to lasers.

1011 Basic Physics I (4)
Prerequisites: Math 1030 and Math 1035; Math 1100 or Math 1800 strongly recommended. A course specifically designed for students in health and life sciences covering the topics in classical mechanics such as kinematics, Newton's laws, energy, momentum and oscillations. This course will not fulfill the Physics 2111 requirement for physics, chemistry, and engineering majors. Three classroom hours and two hours of laboratory per week.

1011A Basic Physics I (3)
Same as PHYS 1011 without the laboratory.

1012 Basic Physics II (4)
Prerequisites: Physics 1011. A continuation of Physics 1011. A course specifically designed for students in health and life sciences covering electricity, magnetism, light, optics and waves. This course will not fulfill the Physics 2112 requirement for physics, chemistry, and engineering majors. Three classroom hours and two hours of laboratory per week.

1012A Basic Physics I (3)
Same as PHYS 1012 without the laboratory.

1050 Introduction to Physics (4)
Prerequisite: Math 1030. A laboratory survey course which introduces students to the fields of mechanics, heat and thermodynamics, optics, electricity and magnetism, and modern physics at the pre-calculus level. A problem-solving course, recommended for science and engineering students who have no physics background or who desire additional preparation for Phys 2111. Three classroom hours and two hours of laboratory per week.

1099 Windows on Physics (1)
A seminar designed to introduce physics majors to research areas in physics and physics-related fields in the Department of Physics & Astronomy. In addition to fundamental areas of physics, the areas of astrophysics, biophysics, materials science, and nanotechnology will be included. Career opportunities for students with physics degrees will be discussed and the physics curriculum will be reviewed. The course meets weekly and is required of all physics majors and minors who are first-time freshmen or transfer students.

2111 Physics: Mechanics and Heat (5)
Prerequisite: Mathematics 1900 (may be taken concurrently). Physics 1001, or Chemistry 1121, or equivalent is recommended. An introduction to the phenomena, concepts, and laws of mechanics and heat for physics majors and students in other departments. Three hours of lecture, one hour of discussion, and two hours of laboratory per week.
2112 Physics: Electricity, Magnetism, and Optics (5)
Prerequisites: Physics 2111 Mathematics 2000. (Math 2000 may be taken concurrently). A
phenomenological introduction to the concepts and laws of electricity and magnetism, electromagnetic
waves, optics and electrical circuits for physics majors and students in other departments. Three hours
of lecture, one hour of discussion, and two hours of laboratory per week.

3200 Mathematical Methods of Theoretical Physics (3)
Prerequisites: Physics 2112 and Mathematics 2000. Mathematical techniques specifically used in the
study of mechanics, electricity, magnetism, and quantum physics are developed in the context of various
physical problems. Course includes the topics of vector calculus, coordinate systems, the Laplace
equation, and its solutions, elementary Fourier analysis, & complex variables. Applications to
electrostatics, mechanics, and fluid dynamics are emphasized. Three hours of lecture per week.

3221 Mechanics (3)
Prerequisites: Physics 3200 and Mathematics 2020. (Math 2020 may be taken concurrently).
Advanced course covering single and many particle dynamics, rigid-body dynamics, and oscillations.
Variational principles and Hamiltonian formulations of mechanics are covered. Three hours of lecture
per week.

3223 Electricity and Magnetism (3)
Prerequisites: Physics 3200 and Mathematics 2020. (Math 2020 may be taken concurrently).
Advanced course covering the rigorous development, from basic laws, of Maxwell’s equations for
electromagnetic fields along with applications of these equations. Topics covered are electrostatics and
electrodynamics including currents, magnetic fields, motion of charged particles in fields and an
introduction to electromagnetic waves. Three hours of lecture per week.

3231 Introduction to Modern Physics I (3)
Prerequisite: Physics 2111, 2112, and Mathematics 2020 (typically taken concurrently) and Physics
3200 strongly recommended (but is typically taken concurrently). Students typically take Math 2020,
Physics 3200 and 3231 in the same semester (see Tentative Schedules above). Photons and the wave
nature of particles; wave mechanics; Schroedinger equation, and applications to single system; atomic
physics and spectroscopy; molecular physics; nuclear models and reactions; the physics of solids;
atomic particles; relativity. Three hours of lecture and one discussion section per week.

3281 Directed Readings in Physics (1-5)
Prerequisite: Consent of instructor. A study of the literature of physics. A paper is required on an
approved topic. Topics must be substantially different from regular courses. Hours arranged.

3390 Research (1-10)
Prerequisite: Consent of department. Independent research projects arranged between student and
instructor. Hours arranged.

3410 Seminar (1)
Presentation of selected papers by students and faculty members at weekly meeting. May be taken
twice for credit.
4306 Nanoscience Practicals (1-3)
Prerequisite: Consent of Instructor (1.0 credit hour per module with a maximum of 3 credit hours)
Studies of nanoscience characterization, synthesis, and modeling techniques designed for clients of these tools, as well as for technical users interested in a current overview. Course consists of a set of 1/3 semester modules. Check with the instructor on more specialized modules (e.g. on materials microscopy) if interested. Each module will cover instrumentation, current applications, weaknesses, and will involve lab visits for hands-on experience, weekly web interaction and classroom hours.

4308 Transmission Electron Microscopy (3)
Prerequisite: consent of instructor. Course introduces students to transmission electron microscopy techniques and their applications to solving challenging materials and biological problems. Course includes fundamental principles (electron optics), electron-specimen interactions, diffraction of electrons, image formation and interpretation, image processing and analysis, energy dispersive X-ray spectroscopy, electron energy loss spectroscopy, and sample preparation of both biological and non-biological systems. Laboratory experiments will provide students "hands-on" experience with TEM operations and problem-solving skills. Successful completion of the course enables students to independently operate transmission electron microscopes to perform basic research experiments. This course is ideal for students interested in ultrastructural or nanocharacterization of biological or materials systems. Two classroom hours and two hours of laboratory per week.

4309 Scanning Probe Microscopy (3)
Prerequisite: consent of instructor. A lecture/laboratory study of research techniques using scanning probe microscopy. Topics include atomic force microscopy, scanning tunneling microscopy, feedback control, scanning tip fabrication, scan calibrations, air/solution/vacuum imaging, image processing and analysis, near-field optical probes, metrology, and lateral force/displacement microscopy. Applications in physics, chemistry, biology, engineering, and surface science are discussed. Two classroom hours and two hours laboratory per week.

4310 Modern Electronics (3)
An integrated recitation/laboratory study of modern analog and digital electronics with emphasis on integrated circuits. Topics include circuit elements, operational amplifiers, logic gates, counters, adc/dac converters, noise reduction, microprocessors, embedded microcontrollers, and digital processing. Six hours of laboratory per week.

4311 Advanced Physics Laboratory I (3)
Prerequisites: Advanced standing with at least nine completed hours of Physics at or above the 3000 levels. Physics majors are introduced to the experimental techniques used in research. A student will choose and do several special problems during the semester. Six hours of laboratory per week.

4323 Modern Optics (3)
Prerequisite: Physics 3223. A study of modern optics including diffraction theory, polarization, light propagation in solids, quantum optics, and coherence.

4325 Topics in Modern Applied Physics (3)
Prerequisites: Physics 4310 and Mathematics 2020. Topics are taken from modern applications of physics, which may include linear analysis, nonlinear analysis, Fourier transform spectroscopy, wavelet
analysis, noise and fluctuation phenomena, material science, physical electronics, optical techniques, and scanning tip microscopy.

4331 Introduction to Quantum Mechanics (3)
Prerequisites: Physics 3200 and 3231. Photons and the wave nature of particles; wave mechanics, Schroedinger equation, operator and matrix formulations, and Dirac notation; applications to single particle systems, atomic physics, and spectroscopy.

4335 Atomic and Nuclear Physics (3)
Prerequisites: Physics 4331. Application of Schroedinger’s equation to hydrogen-like atoms; atomic structure and spectra; nuclear masses, energy levels; alpha, beta, and gamma radiation, nuclear reaction, and models of the nucleus.

4341 Thermal and Statistical Physics (3)
Prerequisites: Mathematics 2000 and Physics 3231. Introduction to statistical mechanics, classical thermodynamics, and kinetic theory.

4343 Selected Topics in Physics I (3)
Prerequisites: Physics 3221, 3223, 3231, 4341. Topics include special phenomena from research areas such as physics of waves, biophysics, nonlinear physics, geophysical fluid dynamics and the atmospheric sciences treated by methods of advanced mechanics, electromagnetism, statistical mechanics, thermodynamics and quantum mechanics. Three hours of lecture per week.

4347 Introduction to Biophysics (4)
Prerequisites: PHYSICS 3231, BIOL 1821, and BIOL 1831; or permission of instructor. Introduction to the application of physical principles to problems in biology. The course will cover topics such as ion transport, protein folding, molecular motors, collective dynamics and self-assembly of biological systems, x-ray crystallography and NMR, a survey of medical imaging techniques, the relation between nonlinear dynamics and electrophysiology in the heart and brain, and physics-based approaches to modeling gene networks and evolutionary dynamics.

4350 Computational Physics (3)

4351 Elementary Solid State Physics (3)
Prerequisite: Physics 4331. Theoretical and experimental aspects of solid state physics, including one-dimensional band theory of solids; electron emission from metals and semiconductors; electrical and thermal conductivity of solids.

4353 Physics of Fluids (3)
Prerequisites: Physics 3221, 3223, and 4341, or consent of instructor. Dynamical theory of gases and liquids. Course covers the mathematical development of physical fluid dynamics with contemporary applications.
4354 Atmospheric Physics (3)
Prerequisite: Physics 4341 and 3221. The mathematical application of physical laws to atmospheric dynamics and physical meteorology. Application of mechanics, thermodynamics, optics and radiation to atmospheric phenomena including the ionosphere.

4356 Quantum Optics (3)
Prerequisites: Physics 3200, 3231, and Mathematics 2020. Review of atomic theory and spectroscopy. Selected applications to modern optical phenomena such as optical pumping, lasers, masers, Mossbauer effect, and holography.

4365 Introduction to Plasma Physics (3)
Prerequisites: Physics 3223 and 4341. A study of the nonlinear collective interactions of ions, electrons, and neutral molecules with each other and with electric and magnetic fields. Topics include plasma confinement and stability, electrical discharges and ionization, kinetic theory of plasma transport, plasma waves and radiation, and controlled fusion. Solutions of the Boltzmann, Fokker-Planck, and Vlasov equations are discussed and methods of advanced electromagnetism and statistical physics are utilized.

4370 Relativity & Cosmology (3)
Prerequisites: Physics 3221, 3223, and 3231. An introduction to Einstein's general theory of relativity. Topics will include special relativity in the formalism of Minkowski's four dimensional space-time, Principle of Equivalence, Riemannian geometry and tensor analysis, Einstein field equation and cosmology.

4381 Directed Readings in Physics (1-10)
Prerequisite: Consent of instructor. An independent study of special topics in physics for senior undergraduates or graduate students.

5307 Advanced Scanning Electron Microscopy (3)
Prerequisite: Consent of instructor. This course introduces students to advanced scanning electron microscopy techniques and their applications to solving challenging materials and biological problems. The course includes electron optics, electron-specimen interactions, image formation and interpretation, compositional analysis by energy dispersive X-ray spectroscopy, and sample preparation of both biological and non-biological systems. Laboratory experiments will provide students “hands-on” experience with SEM operations and problem-solving skills. Successful completion of the course enables students to independently operate scanning electron microscopes to perform research experiments. Two classroom hours and two hours of laboratory per week.

5345 Nonlinear Dynamics and Stochastic Processes (3)
Prerequisites: Phys 3221 and 4341 and Consent of Instructor. Dynamical systems; theory of oscillations; introduction to bifurcation theory and chaos in dissipative systems with applications in physics and biology; introduction to stochastic processes with applications in physics, chemistry and biology; dynamics of nonlinear systems perturbed by noise; noise-induced phase transitions; linear and nonlinear time series analysis. Three classroom hours per week.
5357 Fundamental Particles and Forces (3)
Prerequisites: Physics 3223, 3231 and 4331. Introduction to nuclear and particle physics. Nuclear phenomenology and models; high energy particle accelerators and detectors; phenomenology of strong, electromagnetic and weak interactions; symmetry principles; quark compositions of strongly interacting baryons and mesons; gauge theories and the standard model of particle interactions; grand unification.

5402 Introduction to Mathematical Physics (3)
Prerequisites: Graduate standing in Physics or consent of instructor. A course covering mathematical techniques as applied in advanced theoretical physics including generalized vector spaces and their dual spaces, linear operators and functionals, generalized functions, spectral decomposition of operators, tensor analysis, and complex variables. Three classroom hours per week.

5403 Principles of Mathematical Physics (3)
Graduate standing in physics or consent of instructor. Boundary value problems; Strum-Liouville theory and orthogonal functions; Green's function techniques; and introduction to group theory with emphasis on representations of Lie Algebras. Three classroom hours per week.
VIII. SCHOLARSHIPS, AWARDS, AND FINANCIAL SUPPORT

The Department of Physics and Astronomy offers a number of scholarships and awards, as well as financial support to Physics majors. Money from all scholarships and awards are transferred to individual student accounts and may be applied to tuition and fees. For more information, contact the Undergraduate Advisor (bahars@umsl.edu).

(1) PHYSICS & ASTRONOMY ALUMNI SCHOLARSHIP

New Physics majors with outstanding ACT or SAT scores, or continuing Physics majors with outstanding academic records, are eligible to receive up to $2,000 per academic year. This scholarship may be renewed for up to 4 years provided the recipient maintains a 3.5 GPA. Applications for this scholarship should include an official grade transcript, an official listing of ACT or SAT scores, and a letter of reference from a present or former physics teacher. Application materials should be sent to the Department Chairperson or the Undergraduate Advisor by May 1. Students receiving the Alumni Scholarship are not eligible for the Junior Alumni Award.

(2) THE RICHARD D. SCHWARTZ SCHOLARSHIP FOR PHYSICS MAJORS

The Richard D. Schwartz scholarship, available to full-time junior/senior physics majors in good standing and renewable for up to two years, provides $2,000 per academic year. Applications are due by May 1 and must be from Missouri residents. The scholarship is named in honor of Professor Schwartz who had a distinguished 28 year career at the University of Missouri-St. Louis that included oversight of the construction of the campus observatory and implementation of the astrophysics option program. Professor Schwartz was a pioneer in the study of the energetic winds from young stars and was a premier observational astronomer, using such facilities as the Hubble Space Telescope, the International Ultraviolet Explorer, and the Kuiper Airborne Observatory. He authored over 75 scientific publications and was selected to receive the Chancellor’s Award for Excellence in Research in 1999.

(3) DON C. AND SUSAN P. WINTER ENDOWED SCHOLARSHIP IN PHYSICS & ASTRONOMY.

To be eligible for this award, students must be full-time undergraduates interested in pursuing a degree in physics. The requirements for eligibility are a minimum ACT of 24 (for incoming freshmen) or minimum GPA of 3.0. The award is renewable as long as student continue to meet these criteria. Please contact the department regarding the amount of the award (which may vary) and the application process.

(4) PIERRE LACLEDE/PHYSICS & ASTRONOMY ALUMNI SCHOLARSHIP FOR UNDERGRADUATE PHYSICS MAJORS

Physics majors who are also accepted into the Pierre Laclede Honors College may be eligible for a joint Physics & Astronomy Alumni / Pierre Laclede Honors College Scholarship. The award includes up to $1500 per year from the Department of Physics & Astronomy. In addition, the Pierre Laclede Honors College will add up to a $2000 merit scholarship to make a total award of up to $3500 annually. The full scholarship is renewable for up to four years for freshman awardees who maintain a 3.5 GPA. Students should contact the Honors College advising office for instructions on how to apply.

(5) JUNIOR ALUMNI AWARD

Physics majors who attain a 3.5 average or better in Physics 2111 and 2112 are entitled to receive this award. The award, generally $500, is given to the student in the semester they enroll in Physics 3200. Transfer students must take Physics 2112 on this campus to be eligible for this scholarship.
(6) SENIOR ALUMNI AWARD
This award is given to an outstanding Physics major at the senior level (must earn highest GPA among the senior class) and the amount is generally $500.

(7) JEFFREY EARL AWARD
The Department awards a cash prize (typically $500) to an outstanding graduating senior every May.

(8) UNDERGRADUATE RESEARCH AWARDS
Undergraduate physics majors who identify a faculty mentor and research project may apply for a research award up to $1000 for two semesters. Students receiving this award are required to enroll for at least one credit hour of Physics 3390 and present their research results at the campus Undergraduate Research Symposium in April.

(9) TEACHING ASSISTANTSHIPS
A small number of student teaching assistantships with stipends are available to qualifying students to prepare them for the independent effort required in industry or graduate school. Students are encouraged to talk to professors or the Chairperson about these opportunities.

(10) NASA RESEARCH INTERNSHIP
Research internships for the summer and academic year are available for students interested in astrophysics through the NASA/Missouri Space Grant Consortium.

(11) FINANCIAL AID
The university offers financial assistance to qualifying students in the form of grants, loans, scholarship, and work-study. Complete information on all available financial aid programs is found in the Financial Aid Brochure. Contact the Student Financial Aid Office to obtain a copy.
IX. THE PHYSICS CLUB

The Physics Club on the UM-St. Louis campus was formed in 1971 and continues strong today. It is the glue that holds the life of a physics student together. Through the Physics Club you get to meet all the other physics students, from freshmen through seniors, and on to graduate students. You socialize, network, share information, get help, give help, improve the Department of Physics and Astronomy with in-house projects, and do outreach projects. You learn from each other, and have a lot more fun than you would just going it alone.

The Physics Club holds monthly planning meetings, which include a free pizza lunch. It also holds a minimum of one fun social event per month, open to all physics students and their friends and family. Examples of these social events include: dining out together, taking trips to local science sites, and holding movie nights here on campus. The club also does projects that promote physics to non-physicists, both on our campus and in the larger community.

Our local Physics Club is associated with a national student physics organization, the Society of Physics Students (SPS). This professional physics association, designed explicitly for students, consists of 600 active chapters across the United States. The national SPS provides us with opportunities to participate in national and regional research meetings, where we can present papers and network informally with students from across the country. Some students in our Physics Club opt to join the national SPS for a small fee. These students receive Physics Today magazine, the Journal of Undergraduate Research in Physics and the SPS Newsletter. The SPS also offers scholarships for projects that promote interest in physics among non-physics majors and the general public.

You become a member of the Physics Club automatically, simply by registering as a physics major or minor. To assure that you are on the email list and that you will receive the club notices, you may email the club's faculty sponsor, Dr. Wilking at bwilking@umsl.edu. But most students will be automatically put on the list without having to take any action of their own.
X. TRANSFER CREDITS

Students transferring into the Department of Physics & Astronomy from other colleges/universities may seek assistance from the Chair of the Department to effect as smooth a transition as possible. Here are the criteria for transfer credits:

(1) All astronomy and geology courses from reputable universities, colleges, and junior colleges will receive Natural Science and Mathematics credits.

(2) Only Physical Science courses with a mathematics requirement receive General Education Natural Science and Mathematics credit.

(3) There are two exceptions to (2); Physical Sciences 101 and 124 offered by the St. Louis Community College receive Natural Science and Mathematics credits.

(4) Physical Science courses without a mathematics requirement or courses with titles like "Physics and Society" or "Energy and Environment" do not satisfy the Natural Science and Mathematics distribution requirement. These courses can be transferred as Approved Elective credits and be used to fulfill the 120 hours needed for graduation.

(5) Students who have earned an Associate of Science Degree: Physics Option at one of the St. Louis Community Colleges have an opportunity to complete their Bachelor of Science Degree in Physics at UM-St. Louis. This matriculation agreement is tailored for students seeking a B.S. in Physics: Engineering Physics option. Students can transfer a maximum of 64 credit hours from their Associates Degree to UM-St. Louis and will have to take a minimum of 36 credit hours in upper division physics and mathematics at UM-St. Louis (plus any remaining general education requirements) to complete the B.S. in Physics: Engineering Physics Option degree. Alternatively, students can complete a B.S. in Physics: Astrophysics Option with a minimum of 40 credit hours of upper division physics and mathematics, or a B.S. in Physics: General Physics Option with a minimum of 47 credit hours.
Many of our students have been successful in subsequent graduate studies in astrophysics and meteorology, as well as physics. Our alumni have pursued graduate studies and earned doctorate degrees at institutions such as Cornell University, MIT, University of Wisconsin, University of Chicago and Washington University. Students who have elected for careers in industry are now working in a variety of settings for such firms as Emerson Electric, Hewlett Packard, IBM, Boeing and MEMC Electronic Materials. Several former students are currently teaching physics in high schools around the St. Louis area.