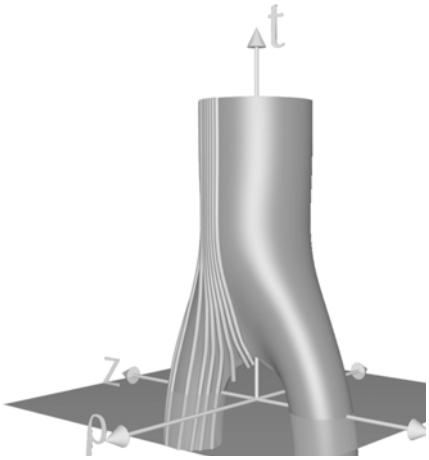
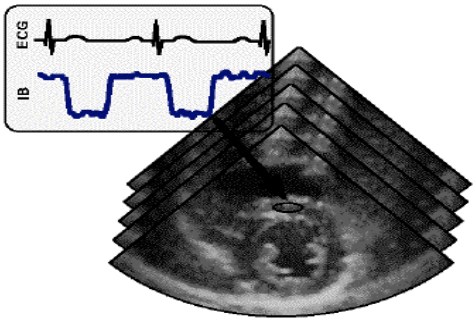
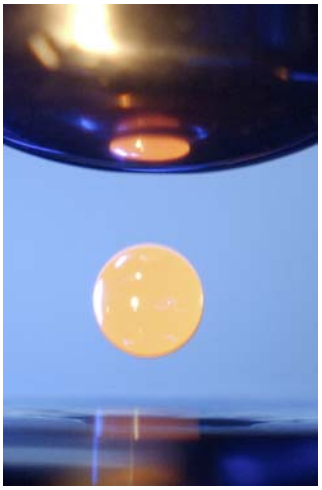
Washington University
St. Louis, Missouri

Department of Physics

Handbook for Majors and Prospective Majors







August 2008

Top Left Picture: Spacetime diagram showing the merging event horizons of two black holes during a head-on collision. The lines show photons trapped on the horizons. Numerical simulations done by our Gravitation Group (WUGRAV).

Top Right Picture: Quantitative ultrasonic images of a physics graduate student's heart depicting the normal cyclic variation of integrated backscatter (IB). This systematic variation in the ultrasonic properties of myocardial tissue was first discovered and reported by researchers here in the Physics Department's Laboratory for Ultrasonics. Measurements of backscatter can be applied to diagnoses of heart disease as well as to the understanding of the physical properties of anisotropic layered composites such as the human heart.

Bottom Picture: Liquid sphere of a titanium-zirconium-nickel alloy at a temperature above its melting temperature. The liquid is levitated in high vacuum by electrostatic levitation using a facility at NASA, Marshall Space Flight Center. Kelton’s group developed techniques to study the structures of such liquids, both above and below their melting temperatures, by synchrotron x-ray diffraction measurements.

Washington University in St. Louis
Department of Physics

Handbook for Majors and Prospective Majors

August 2008

Welcome to the Department of Physics. You are about to embark on an exciting adventure that could find you exploring the boundaries of black holes or fabricating new materials for human benefit. You are going to be challenged to think critically and quantitatively. You may learn your way around a cutting-edge laboratory or master the computer workstation and maybe even a supercomputer. You will learn skills that will serve you well in graduate school, employment in a broad range of fields, or teaching.

This handbook will provide you with the nuts and bolts, the rules and regulations, the people and programs, which make up the physics department and its majors.

What is Physics?

Physics is the discipline that deals with the most fundamental aspects of our universe, such as the properties of atoms, nuclei and elementary particles, the nature of the forces between them, and the collective behavior of atoms in solids, liquids and gases. It deals with the entire universe, from its birth to its ultimate fate. At the same time, physics provides the tools that help us to understand extremely complex, everyday things, such as the behavior of sand piles, the strength of materials, or processes in the brain.

What Good is Physics?

Discoveries in physics surely deepen our intrinsic understanding of the universe, of its governing laws, of its contents and its history. The impact of

physics and physicists outside the field has been equally important. Some examples include:

- NMR imaging -- a standard diagnostic tool in hospitals under the name MRI; it was derived from physicists' techniques for studying nuclear and atomic structure.
- The Global Positioning System -- a multi-billion dollar industry in accurate commercial and military navigation; it uses atomic clocks, developed by physicists, and relativity theory, developed by Einstein.
- The World Wide Web -- who doesn't know what it is? It was developed by particle physicists at CERN who needed a way to transmit data from accelerators to the home universities of the researchers.
- The structure of DNA -- co-discovered by a physicist.

One of the exciting things about physics is its unpredictability: most new discoveries are totally unexpected. Also, the discoveries in ‘‘basic’’ physics of one generation usually have unexpected practical consequences in the next, as the examples above show.

What Good is a Bachelor's degree in Physics?

An undergraduate degree in physics will provide you with the skills to pursue a wide variety of careers, and many people find the subject so fascinating that they go on to pursue Master’s or Ph.D. degrees. Physics bachelors graduates who choose to go straight into full-time employment readily find jobs in industry with very competitive starting salaries: ranging from $34k-54k for the class of 2003 and 2004, U.S.-wide. Five years after obtaining their degrees, these physics graduates have careers in diverse fields, from the software industry to management, finance, education, and the military. Our programs are designed to give you, in addition to the fundamentals of physics, a broad range of skills in laboratory techniques, critical thinking, computer use, and teamwork, which will serve you well in your chosen career.

Table of Contents

The Physics Department

The Department of Physics at Washington University includes 27 professors in tenured or tenure-track positions, 1 Senior Lecturer, 6 research professors, 2 joint professors, 21 adjunct professors, and 95 graduate students, virtually all of whom are Ph.D. candidates. In addition there are 17 departmental support staff, as well as 8 technical staff and 19 post-doctoral fellows and researchers affiliated with research groups.

The department is situated mainly in two buildings: Crow Hall, built in 1934 and Compton Physics Laboratory built in 1964. The Compton Laboratory houses the Pfeiffer Library of Physics, the Laboratory for Space Physics, the Laboratory for Ultrasonics, the NMR Laboratory, the Laboratory for Materials Physics, machine shops, seminar rooms, and many research laboratories and offices. Crow Hall has two floors devoted to research and includes the Center for Materials Innovation, as well as the Laboratory for High-Pressure Physics, laser and biophysics labs. Its other floors are occupied by lecture rooms, teaching laboratories, and offices.

All regular courses in the department are taught by the faculty, with the department's teaching exceeding the university average, as determined from student evaluations. The laboratories of Introductory Physics (117-118 and 197-198) are run by Physics Graduate Teaching Assistants, with faculty and staff oversight. Classes tend to be small, and the faculty-to-majors ratio of about 1 to 1.5 is quite high, making faculty very accessible to students. Research with faculty is strongly encouraged. It can be a rewarding and exciting supplement to regular coursework, as well as an important preparation for graduate school or employment.

The faculty publishes over 100 research articles per year, and receives approximately $5,000,000 in Federal research funds. It includes 8 former Sloan Foundation Fellows, three former Guggenheim fellows, four recipients of Outstanding Junior Investigator Awards from the U.S. Department of Energy, one recipient of an NSF Early Career Award, two members of the National Academy of Sciences, ten Fellows of the American Physical Society, one Fellow of the Institute of Physics (UK), one Fellow of the Acoustical Society of America, and two Senior Members of the American Institute for Ultrasound in Medicine.

Some awards in recognition of the research achievements of our faculty deserve special mention. In 2007, Professor Clifford Will was elected to the National Academy of Sciences, and Professor Carl Bender was honored with Washington University's Arthur Holly Compton Faculty Achievement Award. Professor John Clark has been elected Chair-Elect of the Forum on International Physics of the American Physical Society, and Professor Yan Mei Wang has received a Ralph E. Powe Junior Faculty Enhancement Award from the Oak Ridge Associated Universities. Carl Bender was awarded the prestigious Ulam Fellowship by Los Alamos National Laboratory for 2007 – 2008, and Professor James Miller received an IEEE Achievement Award in 2006, the highest honor bestowed by that society. Within recent years, Professor Carl Bender was elected Fellow of the Institute of Physics (UK). Professors Bender, Will and Israel have been elected Fellows of the Academy of Science of St. Louis, and Professor James Buckley has received the Academy's Innovation Award. In earlier years, Professor James Miller was honored for his scientific contributions through MERIT status for funding by the National Institute of Health (NIH). Professor Clifford Will received the American Institute of Physics Award for Science Writing for his book *Was Einstein Right?* and has been elected Fellow of the American Academy of Arts & Sciences. Professor John Clark was awarded the Feenberg Medal for Many Body Physics.

Several of the faculty have also received rewards for excellence in teaching. Professor Carl Bender received the Burlington Northern Faculty Achievement Award, while Professors Willem Dickhoff and Michael Friedlander received Kemper awards for teaching innovation. In 2007, Professor James Miller was honored with the Emerson Award for Excellence in Teaching.

The exceptional academic and scientific leadership demonstrated by six of our faculty have been recognized in their appointment to endowed chairs: Carl Bender is the Wilfred R. and Ann Lee Konneker Professor of Physics John Clark is the Wayman Crow Professor of Physics, Kenneth Kelton is the Arthur Holly Compton Professor of Physics, James Miller is the Albert Gordon Hill Professor of Physics, Stuart Solin is the Charles M. Hohenberg Professor of Experimental Physics, and Clifford Will is the James S. McDonnell Professor of Physics.

During the 2005 World Year of Physics, the American Physical Society designated Washington University and our department as one of the first five institutions to be entered into the registry of historical sites of American physics. This designation recognizes the fundamental importance of

Compton's experiment demonstrating the particulate character of light, performed on this campus in the early 1920's.

The Physics library is one of the outstanding resources available to all students. The collection, valued at approximately $7,000,000, contains over 46,000 books and bound periodical volumes. The library subscribes to hundreds of print and electronic journals. It has an online catalog that is linked to all academic libraries in the state of Missouri with borrowing privileges from any of them. Terminals are available in the library for Internet access and students can also do their own searching on comprehensive electronic databases such as INSPEC and Web of Science.

The Physics Department has extensive computer resources, from desktop workstations to high-performance clusters. All undergraduate majors, graduate students, staff and faculty have access to departmental computing resources, including email and web access, as well as software tools such as Matlab, Maple, and Mathematica. There are a number of research-group computer systems in the department, and a High Performance Computing Center (HPCC) comprising more than 50 64-bit processors running the Red Hat GNU/Linux operating system. The HPCC is available to all Physics Department faculty, researchers, and students, and is used for data analysis, instrument simulation, astrophysical simulation, numerical general relativity, lattice gauge calculations, and more. Many faculty members are engaged in strong research programs in scientific computing, making extensive use of these resources, as well as national supercomputer facilities. Undergraduate participation in these projects is encouraged.

The Department of Physics of Washington University is strongly committed to fundamental research and excellence in teaching. The goal of the major program is to provide undergraduate students with an outstanding education in physics as preparation for successful careers in graduate school or in the workplace.

Requirements for the Major in Physics

Physics requirements
Specific requirements for the Major in Physics include successful completion of two semesters of calculus-based introductory physics:

- General Physics I Physics 117A (4 units)
- General Physics II Physics 118A (4 units)

OR

- Physics I Physics 197 (4 units)
- Physics II Physics 198 (4 units)

Students who intend to major in Physics are strongly encouraged to take the Physics 197/198 sequence.

Additionally, students will need to take at least seven courses at the 300 level or above (with the exception of Physics 303, 304, 341, 342, 441, 442, 499, 500). Specifically required courses include:

- Physical Measurements Lab Physics 322 (3 units)
- Mechanics Physics 411 (3 units)
- Electricity and Magnetism I Physics 421 (3 units)
- Quantum Mechanics Physics 217, 318 or 471 (3 units)

In addition, one more upper level laboratory course is required. Students may select one of the following upper level labs: Optics & Wave Physics Lab (Physics 316), Electronics Lab (Physics 321), Biophysics Lab (Physics 360), or Advanced Lab (Physics 451 / 452). The remaining courses can be selected from the other courses offered by the Department including some at the 500 level. The package of courses selected can be quite different for a student planning to enter the work force after graduation and one who wishes to enter a graduate program in physics. Several examples of typical programs with different emphasis are provided below. Programs can be tailored to individual needs and interests and should be chosen in consultation with your major advisor. Grades in the 300 level courses or above must be C- or better.

Science-Breadth Requirement
Because the physical sciences are inherently interdisciplinary, the Physics faculty believe that an undergraduate education in Physics should be broader

than the traditional boundaries of Physics. The science-breadth requirement consists of courses in other science departments which complement the Physics curriculum and offer insight to the truly interdisciplinary nature of science.

Students should select 3 courses from the following list to satisfy the science-breadth requirement. One of the courses must be Chem 111,112, 401 or 402.

- General Chemistry I (Chem 111)
- General Chemistry (Chem 112)
- General Chemistry Lab I (Chem 151)
- General Chemistry Lab II (Chem 152)
- Physical Chemistry I (Chem 401)
- Physical Chemistry II (Chem 402)
- Instrumental Methods: Physical Chemistry (Chem 445)
- Introduction To Computer Programming (CSE 126)
- Computer Science I (CSE 131)
- Computer Science II (CSE 132)
- Engineering and Scientific Computing (CSE 200)

Mathematics requirement

To complete a major in Physics, students will also need to take Calulus I, II, and III (Math 131, 132, 233) and Differential Equations (Math 217). Depending on your interests and future plans, additional math courses may be appropriate. Other recommended mathematics courses are discussed on page **XX**.

Requirements for the Minor in Physics

Science majors and other students who are already required to take calculus-based introductory physics (Physics 117A/118A or 197/198) and who have an interest in modern physics and its applications are encouraged to consider a Minor in Physics.

Physics requirements

Specific requirements for the Minor in Physics include successful completion of:

• General Physics I and II	Physics 117A/118A	(4 units/4 units)
OR		
• Physics I and II	Physics 197/198	(4 units/4 units)

Additionally, students must also take:

• Intro Quantum Physics I	Physics 217	(3 units)
• Intro Quantum Physics II	Physics 318	(3 units)

followed by at least one elective course at the 300 level or above (with the exception of Physics 303, 304, 341, 342, 441, 442, 499 and 500) with a grade of C- or better.

Mathematics requirements

Co-requisite for taking General Physics I (Phys 117A) is enrollment in or placement out of Calculus I (Math 131). Calculus II (Math 132) is a co-requisite for Physics I (Phys 197). Calculus II is also necessary to provide adequate preparation for Phys 217/318 (Quantum Physics I, II) and Calculus III (Math 233) is a co-requisite of Phys 217. Note that for some advanced courses Differential Equations (Math 217) are pre-requisite.

Advisors: Patrick Gibbons (Compton 366, pcg@wustl.edu)
Rebecca Trousil (Crow 214; trousil@wustl.edu)
Jason Woods (Compton 355; woods@wustl.edu)

Requirements for the Minor in Biomedical Physics

The Physics Department offers a minor for students interested in the methods and techniques of physics as applied to topics in the area of biology and medicine. The program is of interest to the research oriented science major or the pre-medicine student.

Physics requirements
Specific requirements for the Minor in Biomedical Physics include successful completion of:

• General Physics I and II	Physics 117A/118A	(4 units/4 units)
OR		
• Physics I and II	Physics 197/198	(4 units/4 units)

Two courses from the following five are required:

• Physics of the Heart	Physics 314	(Spring)
• Physics of the Brain	Physics 350/450	(Fall or Spring)
• Intro Biomedical Physics	Physics 351	(Fall)
• Physics of Biomolecules	Physics 352	(Spring)
• Physics of Vision	Physics 355/455	(Fall or Spring)

In addition, one advanced laboratory course is required. At present any of the following four courses can be chosen:

• Optics & Wave Physics Lab	Physics 316	(Spring)
• Electronics Lab	Physics 321	(Fall)
• Biophysics Lab	Physics 360	(Fall)
• Physical Measurements Lab	Physics 322	(Spring)

The last requirement is intended to give students hands-on experience. For further information, contact Anders Carlsson
(x5-5739; aec@wuphys.wustl.edu) in the Physics Department.

Mathematics requirements (see Physics Minor)
Advisors: Anders Carlsson (x5-5739; aec@wuphys.wustl.edu)
Rebecca Trousil (x5-4495; trousil@wustl.edu)

The Physics Major

The A.B. degree in Physics is awarded by the College of Arts and Sciences.

Freshman and Sophomore Years

Any student interested in majoring in the Physical Sciences is strongly encouraged to take two semesters of calculus-based introductory physics (Phys 117A/118A or Phys 197/198) in their freshman year. For research oriented students in the life sciences this may also be considered appropriate advice. The course structure in the science departments is such that the Biology curriculum explicitly builds on the introductory chemistry sequence, while the introductory chemistry courses are much better understood by the concurrent enrollment in introductory physics (Phys 117A/118A or Phys 197/198). Although it is difficult for some pre-medicine students to include the introductory physics course in their freshman or sophomore year, it is the view of the department that the study of chemistry and subsequently biology is greatly enhanced by a solid background in physics.

Students who intend to major in Physics or who have a special interest in Physics are strongly encouraged to enroll in Physics I and II (Phys 197/198). Physics 197/198 emphasizes the development of a deep understanding of the unifying principles of classical and modern physics through active learning, including intensive self-study, in-class participation, and daily problem solving.

Concurrent enrollment in Calculus I (Math 131) is required for enrollment in Physics 117A while concurrent enrollment in Calculus II (Math 132) is required for Physics 197. For further discussion of the role of Math courses for the Physics Major see p**XX**. The contents of the introductory courses in Chemistry and Physics are coordinated in such a way that optimal preparation for the Physics Major (and Chemistry Major) is obtained by enrolling in both courses simultaneously. A student who majors in physics is required to take Phys 117/118 or Phys 197/198. In the sophomore year, most physics majors take Intro to Quantum Physics I and II (Phys 217 and 318). This yearlong sequence should be regarded as the continuation of the freshman course and provides students with a solid introduction to quantum mechanics and its applications.

Courses in the Physics Department are offered either in the spring or in the fall, not both semesters. A list of courses and the semester in which they are offered is given on page 2X-2X. One of the trenths of the Physics major at Washington University is that it can be tailored to our individual interests. Two common paths for the first two years of a Physics major are listed below (many different versions are possible):

Program for a Physics Major

A typical program for a Physics Major with some high school preparation in Calculus (that permits placement out of Calculus I) will consist of:

1st year Fall	**Credits**	**1st year Spring**	**Credits**
Phys 197 (Phys I)	4	Phys 198 (Phys II)	4
Math 132 (Calculus II)	3	Math 233 (Calculus III)	4
Chem 111 (Gen. Chem I)	3	Chem 112 (Gen. Chem II)	3
Chem 151 (Chem Lab)	2	Chem 152 (Chem Lab)	2
Elective or English Comp	3	Elective or English Comp	3

2nd year Fall	**Credits**	**2nd year Spring**	**Credits**
Phys 217 (Quantum Phys I)	3	Phys 318 (Quantum Phys II)	3
Upper Level Physics Lab	3	Phys 411 (Mechanics)	3
Math 217 (Diff. Eq.)	4	ESE 317 (Engineering Math)	4
Electives	6	Electives	6

Note: The upper level lab suggested in Fall of the sophomore year could instead be taken in the Spring semester of that year.

Students are encouraged to sample other introductory science courses during their first two years. Principles of Biology I and II (Bio 2960, 2970) are relevant for majors interested in applications of Physics to medicine and biology. Bio 2960 can then be taken in the spring of the sophomore year. A student more interested in the physical sciences may consider Earth and the Environment (EPSc 201) that is offered both in the fall and in the spring by the Earth and Planetary Science department. In general, it makes sense to pursue a broad introduction and survey all fields of science. This broad introduction is not a prerequisite for all careers in physics but is becoming more important for current research in interdisciplinary fields.

Pre-medicine students majoring in Physics

Students can fulfill the pre-medicine requirements while pursuing a Major in Physics. Medical school admission committees consider a Physics Major an excellent preparation for students applying to medical school. In general, the exposure to hands-on applications of physics techniques in the laboratory can be a great advantage for research-oriented students interested in medical school. The program listed below assumes that the incoming student places directly into Calculus II. Other schedules can be devised based on individual needs and preparation.

1st year Fall	**Credits**	**1st year Spring**	**Credits**
Phys 197 (Phys I)	4	Phys 198 (Phys II)	4
Math 132 (Calculus II)	3	Math 233 (Calculus III)	4
Chem 111 (Gen. Chem I)	3	Chem 112 (Gen. Chem II)	3
Chem 151 (Chem Lab)	2	Chem 152 (Chem Lab)	2
Elective or English Comp	3	Elective or English Comp	3

2nd year Fall	**Credits**	**2nd year Spring**	**Credits**
Phys 217 (Quantum Phys I)	3	Phys 318 (Quantum Phys II)	3
Math 217 (Diff. Eq.)	4	Bio 2960 (Princ. Biology I)	4
Chem 251 (Org. Chem I)	3	Chem 252 (Org. Chem II)	3
Phys 3XX (Biological Phys)	3	Chem 257 (Org. Chem Lab)	2
Elective	3	Elective	3

The Physics department is in the process of developing a major in Biophysics, which will have requirements that are different from the regular Physics Major. For more information, contact Prof. Anders Carlsson (aec@wuphys.wustl.edu).

Advanced Placement

If you have taken AP Physics exams in high school and submitted the results to Washington University Admissions, the appropriate AP credit will automatically be added to your internal record. A detailed description of the Physics AP policy can be found in the Bulletin of the College of Arts & Sciences.

A score of 5 on the AP Physics C - Mechanics exam earns 4.0 units of credit for Physics 117. This corresponds to the first semester in a two semester, calculus-based introductory physics sequence. A score of 5 on the AP Physics C - Electricity & Magnetism exam earns 4.0 units of credit for Physics 118. This corresponds to the second semester in a two semester, calculus-based introductory physics sequence. Although students may place out of the first year of calculus-based introductory physics with AP credit, potential majors are strongly encouraged to enroll in Physics 197 (Fall semester) and Physics 198 (Spring semester) during their freshman year.

Contact Rebecca Trousil (trousil@wustl.edu) with questions regarding AP credit or course enrollment.

Laboratories

Laboratory courses provide hands-on opportunities for students to connect experimental observations with the knowledge and mathematical formalism obtained in traditional lecture courses. Moreover, many students report that laboratory courses provide them with a set of experiences upon which to hang the more abstract results from the classroom. Many students speak of the intellectual *fun* of witnessing abstract theories turn into concrete meter readings. Students often report that laboratory courses empower them because they now understand more of what they observe around them (being confident that they *could* learn about the rest).

All majors are required to take Physical Measurements Lab (Phys 322), and at least one other upper level lab course. Students who double major in Electrical Engineering (EE) and Physics need not take Phys 321 (Electronics Lab), but instead should take either Optics & Wave Physics Lab (Phys 316) or Biophysics Laboratory (Phys 360). EE lab courses are not acceptable as substitutes for Phys 321.

The four upper level laboratory courses are Optics & Wave Physics Lab (Phys 316), Electronics Lab (Phys 321), Physical Measurements Lab (Phys 322) and Biophysics Laboratory (Phys 360). The optics course provides the student with an introduction to ray and especially wave optics. Given the explosion of interest in optics driven by light-wave (fiber optics) communication, the optics laboratory is an important course. The electronics laboratory aims to make the student capable of using electronic circuitry and instruments. The biophysics

laboratory course consists of "tabletop" experiments in biological physics designed to introduce the student to the concepts, methods, and biological model systems in biophysics. The physical measurements laboratory is about one-half "great experiments" (Einstein photoelectric effect, Millikan oil drop, etc.) and one-half modern experiments that may relate to other disciplines. One such experiment involves nuclear magnetic resonance, which connects to quantum physics by the Zeeman effect and has applications in chemistry, biology, and medicine (referred to as Magnetic Resonance Imaging or MRI). The experiments in this course are pursued in greater depth than in the other laboratory courses, so physical measurements laboratory has more of the feel of actual research.

Students who are not planning to continue to graduate school are strongly encouraged to take as many laboratory courses as possible. It is possible to take Advanced Labs 1 and II (Phys 451 and 452), as well as the Nuclear and Radiochemistry Laboratory (Chem 435). Other experiments in the advanced chemistry labs are also of great interest. Students who prepare for graduate school are reminded that the vast majority of Ph.D. degrees in physics are awarded for work in experimental physics.

Junior and Senior year

When a student reaches junior standing it should be clear what kind of physics major the student wants to pursue. The range of possibilities is very broad and includes a major with a large number of graduate courses that are offered by the department as well as a major more geared towards applications of physics, for example in Biology and Medicine or Earth and Planetary Science.

Physics 482/582 Research Seminar

An optional course designed to introduce students to current developments in physics and to research carried out by faculty. Topics vary each year. Each member of the department addresses issues in their particular specialty. Interested undergraduates are advised to take this seminar in their junior year.

Credit: 1 unit.

Standard preparation for Graduate School in Physics

A typical program is shown below assuming that Mechanics (Phys 411) has been taken in the spring of the sophomore year (can also be taken junior year).

3rd year Fall	Credits	3rd year Spring	Credits
Phys 421 (Elect & Mag I)	3	Phys 422 (Electr & Magn II)	3
Phys 321 (Electronics Lab) or		Phys 322 (Phys Meas Lab)	3
Phys 463 (St Mech&Thermo) or		Science, Math, or Phys course	3
Phys 471 (Quantum Mech I)	3	Electives	6
Science, Math, or Phys course	3		
Electives	6		

A large selection of advanced courses is available to complement your preparation for graduate school during the Fall and Spring Semester of your senior year. Note, however, that courses like Phys 472 (Intro Solid State Physics) and Phys 474 (Intro Nuclear & Particle Phys) have Phys 471 as a prerequisite, and they are not necessarily offered every year. Also courses at the graduate level like Phys 501/ 502 (Methods of Theoretical Physics I / II) and many others are available. Students preparing for graduate school in physics should take more physics courses than the minimum required for the major. Consult your major advisor for advise on courses that will best prepare you for your future studies.

Students preparing for employment after the A.B.

Students who are not planning to continue to a graduate program in physics are also required to take Phys 411 (Mechanics), Phys 421 (Electricity & Magnetism I) and Phys 322 (Physical Measurements Lab). In addition to these courses you are advised to focus on course work involving the applications of physics in a more or less practical setting. Special emphasis should be placed on the laboratory courses

Physics 316	Optics & Wave Physics Lab
Physics 321	Electronics Lab
Physics 360	Biophysics Laboratory

Other courses that have particular relevance are:

Physics 314	Physics of the Heart
Physics 350	Physics of the Brain
Physics 351	Intro Biomedical Physics
Physics 352	Physics of Biomolecules
Physics 355	Physics of Vision
Chemistry 401	Physical Chemistry I
Physics 422	Electricity & Magnetism II
Physics 427	Intro Computational Physics
Chemistry 435	Nuclear & Radiochemistry Lab
Chemistry 436	Radioactivity & Applications
Physics 451	Advanced Laboratory I
Physics 452	Advanced Laboratory II
Physics 463	Statistical Mechanics & Thermodynamics
Physics 464	Physics of Continuous Media
Physics 471	Quantum Mechanics I
Physics 472	Intro Solid State Physics

Some packages will prepare students very well for graduate school in other sciences as well as medical school (see below).

Students preparing for Medical School

Pre-medicine students still face some required courses in their junior year. These include the continuation of the Fundamentals of Biology sequence. A possible schedule would then be as follows

3rd year Fall	**Credits**	**3rd year Spring**	**Credits**
Phys 360 (Biophysics Lab)	3	Phys 314 (Phys of the Heart)	3
Phys 421 (Electr. & Magn I)	3	Phys 322 (Phys Meas Lab)	3
Bio 2970 (Princ. Biol II)	4	Phys 411 (Mechanics)	3
Electives	6	Electives	6

In the senior year at least one additional course for example Phys 350 (Physics of the Brain), Phys 352 (Physics of Biomolecules), or Phys 355 (Physics of Vision). Phys 427 (Intro Computational Physics), Phys 463 (Statistical Mechanics & Thermodynamics), and Phys 471 (Quantum Mechanics I) are also relevant courses to complement your program. Depending on your individual interests and preparation many different schedules can be devised in consultation with your advisor.

Research Projects for Undergraduates

Physics majors with proper qualifications are strongly encouraged to participate in departmental research. The excellent ratio of physics majors to physics faculty provides for a multitude of exciting research opportunities. Many of the research groups can use skills that undergraduates already possess. You learn what physics research is about by doing it. Often students report their work at meetings like the annual Midwest Solid-State Conference, various meetings of the American Physical Society, or as co-authors on papers published in refereed journals. Students can work for nothing more than the experience, for credit in one of our special topics courses, or for money. Research work cannot earn both credit and money.

The ways to enter a research group are watching for ads posted seeking undergraduate research participants, visiting professors whose work interests you, asking your instructor in a physics course or your physics major advisor about possibilities, and circulating a resume - one page describing your experience and interests. The department office will do the copying and delivery to our mailboxes. It is often wise for all involved to begin working as a volunteer and, once established, ask about pay or academic credits. Usually we suggest that freshmen not start with research groups, but use the first year to acclimate to Wash U. At the start of the sophomore year, we will try to match students with research groups, depending on individual interests.

Areas of active departmental research include theoretical and observational astrophysics and space science; mathematical physics; theoretical studies in solid state, elementary particles, and many-body systems; experimental research in materials, solid state, high pressure, nmr, and ultrasonic physics, and in applications of physics to biological and medical problems.

Research groups that have welcomed undergraduate participants recently include Professor Miller's Laboratory for Ultrasonics, in which ultrasound is used to characterize and image composite materials ranging from graphite-epoxy airplane parts to heart muscle (see cover). Professor Wessel studies the biophysics of computation in brains, applying methods from electrophysiology, pharmacology, and imaging to functional brain slices. Professor Carlsson uses a combination of Brownian-dynamics simulation and analytic theory to elucidate the nanoscale proceses underlying the motility of biological cells. Professor Wang welcomes undergraduate students to participate in single molecule biophysics research that uses quantitative experimental methods to address

fundamental biological questions at the molecular level. One major project is to study gene regulations by directly imaging the interactions of single gene regulator proteins with DNA.

The General Relativity Group of Professors Will and Suen involves undergraduates in their work. Professor Suen's general relativity theory group studies exotic phenomena like the collision of two black holes (see cover).

Professor Kelton and Professor Gibbons's materials physics group makes, characterizes, and studies the unique properties of quasicrystals and related metal alloys. Professor Solin's research is focused on the fundamental physics of novel materials, such as semiconductor-metal composites, with a particular interest in the effect of external perturbations (electric fields, magnetic fields, temperature, stress/strain, etc.) on the structural and transport properties of mesoscopic systems (typical size < 100 nm). Professor Conradi's experimental nuclear magnetic resonance group poses and answers a variety of physical and chemical questions about molecular solids, hydrogen-storage alloys, and other materials. They are also developing new methods and applications of magnetic resonance imaging of human lungs.

The McDonnell Center for the Space Sciences, which partly resides on Compton's fourth floor, involves undergraduates in the study of extraterrestrial materials using state-of-the-art microscopic probes and isotope-resolving mass spectrometers. The faculty involved are Professors Bernatowicz, Hohenberg, and Zinner. The cosmic ray, X-ray and gamma-ray groups of professors Binns, Buckley, Israel, and Krawczynski designs, makes, and uses sophisticated detectors for balloon, satellite, and shuttle flights. Professor Krawczynski welcomes undergraduate students to work on the analysis of X-ray observations of the collimated plasma outflows from supermassive black holes. Professor Cowsik's research is in high-energy astrophysics, cosmic rays and dark matter-cosmology; he is also setting up a laboratory for studying the behavior of gravitation at short distances and for searching for new forces of nature.

Professor Alford calculates properties of ultra-dense quark matter, and investigates how it may affect the observable features of neutron stars. Professor Schilling's experimental group uses a diamond-anvil cell to study high-temperature superconductors under pressures approaching one million atmospheres. Professor Bender applies sophisticated mathematical techniques to a range of interesting problems in physics, field theory in particular, and mathematics. Professor Clark involves undergraduates in studying the

properties and applications of neural nets after you have taken his Physics of the Brain course. Professors Ogilvie and Bernard study the theory of the strong interaction, in some cases involving heavy number crunching. Professor Dickhoff studies the quantum effects of particles embedded in a medium of strongly interacting particles like electrons, nucleons, or strange particles.

New projects begin every year, so this list maybe obsolete by the time you read it. Visit our labs and offices and ask what we are doing.

Undergraduate Research Fellowships: There are several Hoopes summer research fellowships and a Delos summer research fellowship that are awarded to students for undergraduate research within one of the department's research groups during a summer. Each spring, applications are solicited by the department and by the Undergraduate Research Office, and selections are made by a joint committee. Students who have received these fellowships often continue to pursue the research during the school year and beyond, which has led to peer-reviewed publications in many cases.

Academic Honors

Degrees may be awarded with honors to students who have maintained an appropriate overall grade point average through eight semesters, and have satisfied the Physics department's own requirements. In the College of Arts and Sciences, there are three levels of honors for the A.B. degree: cum laude, magna cum laude, and summa cum laude corresponding to overall grade point averages of 3.5, 3.65 and 3.8 respectively.

The Department requires honors students to undertake a research project with a research group and, at the end, write a senior thesis that describes the work. This report should be completed by March of your senior year. Students who wish to be considered for honors must start by consulting the Director of Undergraduate Studies or their own advisor before the start of the senior year. Permission of the Department, through the major advisors, must be obtained before a student is allowed to start on an honors project. An application for admission to the honors program must contain an outline of the type of work that will be undertaken. It is the responsibility of each student to seek out a research group and ascertain that the group is able to accommodate the student.

Students may enroll in Physics 499 and receive three units of credit for research work. Some students are paid for their work in research groups, but in such cases credit cannot be awarded though the work can still count towards honors.

Double Majors

Many students have the interests and ability to major in two subjects. This takes some planning, and should be discussed with your advisor. A variety of double major combinations are possible. We have had students major in physics and chemical engineering, electrical engineering (quite frequently), computer science, biology, chemistry, drama, economics, English, French, history, Japanese, philosophy, music and quite often mathematics.

Society of Physics Students

There is a WU chapter of this national society. For a nominal fee, you receive *Physics Today*, published monthly by the American Institute of Physics. The Society holds meetings during the year, with student speakers describing their projects and with faculty and some outside speakers as well as occasional field trips. Dr. Trousil and Professor Gibbons moderate these activities. Their success depends greatly on the active participation of all physics majors.

Advising

If you have indicated during your application process to Washington University that you are interested in pursuing a physics major, it is quite likely that your freshman advisor is a physics faculty member. If this is not the case, it is always relatively easy to switch to one. Students who declare themselves Physics majors will be assigned a faculty advisor. See Patrick Gibbons for an assignment from among the Department's major advisors. Currently, the department has the following faculty who are involved with advising physics majors:

Professor	Office	Telephone	e-mail
Mark Alford	Compton 358	5-5034	alford@wuphys
James Buckley	Compton 253	5-7607	buckley@wuphys
Mark Conradi	Compton 372	5-6418 or	msc@wuphys
	64-75	5-6292	

Willem Dickhoff	Compton 371	5-4169	wimd@wuphys
Patrick Gibbons	Compton 366	5-6271 or 5-4654	pcg@wuphys
Martin Israel	Compton 250	5-6263	mhi@wuphys
Michael Ogilvie	Compton 356	5-6256	mco@wuphys
Rebecca Trousil	Crow 214	5-4495	trousil@
Jason Woods	Compton 355	5-6220	woods@wuphys

Note that the complete e-mail addresses still require the addition of ".wustl.edu" in addition to the user name and local computer given in the table. All physics majors are strongly encouraged to discuss their plans for the major with their advisor in great detail. Some general advice is contained in this handbook but your advisor has access to additional resources and information.

Mathematics and Computing

A good foundation in mathematics and well-developed computer skills are needed for a successful career in physics today. In addition, a background in physics and computing can lead to careers in many technical fields. Your interests and objectives will determine the precise courses in mathematics and computing you will take. For those who are interested in computational aspects of physics, we have a number of faculty members who will be able to describe the role of computers in modern physics research and opportunities for undergraduate research, honor theses, and summer employment. Courses are available in the Department of Mathematics, the Department of Computer Science and Engineering (CSE) and the Department of Electrical and Systems Engineering (ESE).

Computer and computing skills

Students' computing backgrounds vary greatly. At a minimum, the Physics Department recommends familiarity with at least one modern programming language, preferably C, C++ or Java, although Fortran is still used frequently in physics. CSE 200 (Engineering and Scientific Computing) is a one semester introduction to numerical methods with an emphasis on applied physics and engineering problems. The CSE 131-132 sequence is more suited for those with a strong interest in computer science. The physics department offers Physics 427 (Introduction to Computational Physics) which provides a broad introduction to the relationship of physics, computing and mathematics.

Although no previous computer programming experience is required, some exposure to simple programming is helpful.

Courses in Mathematics

The Mathematics department offers extensive options for calculus. Students who have had a year of high school calculus will normally enroll in Math 132, but the precise placement is best determined by taking the on-line calculus placement exam offered by the Math department (http://math.wustl.edu/placement/).

Math 217 (Differential Equations) is required for Physics 411 and 421, which are both required for a physics major. We recommend that students complete Math 217 prior to taking physics 411. Students should also take Math 233 (Calculus III), which is a co-requisite for Math 217, and seriously consider ESE 317 (Engineering Mathematics) or Math 308 (Mathematics for the Physical Sciences), which provide a broad survey of advanced mathematics. We recommend students take ESE317 or Math 308 prior to Physics 421. We also recommend taking Math 309 (Matrix Algebra) prior to enrolling in Phys 471. Students with a strong interest in mathematics or theoretical physics should also consider Physics 501-502 (Methods of Theoretical Physics), which are cross-listed as Math 501-502.

Department computing facilities

In addition to the Arts and Sciences facilities, the Physics Department has a number of computing facilities for undergraduate physics majors. We have a network of Linux servers and Linux, Mac, and Windows workstations. Mathematica, Maple and Matlab are available on the servers for symbolic and numerical computation. Programming languages including C++, Fortran, Java and Lisp are available on the servers and workstations, as are standard facilities for document preparation, visualization, and software development. The High Performance Computing Center hosts clusters for large scale computation.

Putnam Mathematical Competition

Professor Bender of the Physics Department and Professors Rochberg and of the Mathematics Department coach the students who are preparing to enter the Putnam Mathematical Competition. They organize training sessions every Friday afternoon during the fall for the roughly twenty students who like to

practice for this most prestigious annual examination. If you would like to learn techniques of problem solving and would enjoy interacting with this peer group of bright students you are most warmly invited to attend the practice sessions. During the last twenty years Washington University has had four first-place and four second-place finishes. We typically place about half a dozen students in the top 100 and about a dozen students in the top 200. The Washington University team has been one of the three top teams in the country for the last twenty years (of the many hundreds of colleges and universities from the US and Canada that participate).

Physics Library

The Pfeiffer Physics Library is located on the third floor in Compton Hall. This is an outstanding facility, with subscriptions to hundreds of print and electronic journals and a first-rank book collection. The Librarian is available during normal hours to provide professional help. All full-time students who have declared as physics majors may, however, enter the library at any other time - access is controlled by a card-reader that will accept all university ID cards that the Department has validated.

The professional journals constitute the core of the research arm of the library, and we have all of the major journals in our research areas, from the Astrophysical Journal through to Solid State Physics. Some of these come out weekly, others are monthly, and there are also publications such as the Annual Reviews of Nuclear and Particle Physics that contain broad surveys of recent developments in each sub-field.

Weekly publications such as Nature and Science contain both short original research reports that require rapid publication as well as general reports of happenings that affect the scientific community: debates in the Congress on the science budget, international scientific congresses, and ethical issues in science. Other publications deal with the history of science and with science teaching.

The university's main library, Olin Library, contains the major part of the collection in the history and philosophy of science, while other areas of science are housed in separate libraries in the Departments of Biology, Chemistry, Earth and Planetary Science, and Mathematics.

We encourage our students to make use of the library and to seek the help of the Librarian as may be needed.

Prizes

The Department of Physics awards prizes to students who have excelled in various ways.

Robert N. Varney Prize
This prize is awarded each year to the best student in the introductory courses (Phys 117-118, Phys 197-198). Professor Varney was a member of the faculty for many years, carrying out research in gaseous electronics. This prize was established to commemorate his deep and long-time interest in physics instruction. The Varney prize is presented each fall semester at a mid-week department colloquium before a distinguished visitor delivers the annual Feenberg Lecture, in memory of one of our faculty colleagues.

Greg Delos Prize
Greg Delos was an excellent student who died during his junior year. In his memory, the Delos family has generously set up the fund that supports an annual award, that takes the form of a stipend to support a student working with one of the research groups during the summer. The availability of this prize is publicized each spring semester and the winner is selected, by the departmental prize committee, from among the applicants, with selection based on performance in the physics courses (and possibly research) thus far.

The Senior Prize
Awarded each year, the prize is in the form of a plaque and a check. Selection is based on performance in physics courses and is made by the department's major advisors. This Prize is awarded in a ceremony in the Department after Commencement.

It is appropriate to mention another prize that is related to undergraduate courses. The Franklin B. Shull Prize is awarded each year to the outstanding graduate teaching assistants. Frank Shull was the senior faculty instructor in introductory courses for many years, and the prize takes note of both his interest and the importance that the Department attaches to the quality of teaching by graduate teaching assistants.

Career Paths from a Physics Major

What can you do with a Physics Major? Just about anything. Physicists are at the forefront of research and innovation in many areas both industrial and academic. To give a few examples, in industry, physicists develop new technologies to treat diseases and to understand the genome; they invent new generations of electronic equipment and develop technology that will enable us to generate energy from our natural resources more easily, more economically, and more safely. In academia, physicists work on revealing the origin and fate of the universe, understanding the very nature of space, time and matter, and predicting the long-term evolution of the world climate.

Many students go directly from undergraduate studies into a graduate program; others choose jobs in a variety of technical and non-technical fields. Our students often find surprising applications of their physics education to problems that at first glance appear to have little to do with physics. The fundamental reasoning, calculation, and laboratory skills have broad application throughout society.

Physics majors from our department have gone to graduate school in a variety of scientific fields, to business school and medical school. With an undergraduate degree in physics, you can pursue graduate studies in:

* Physics
* Chemistry
* Biology
* Earth and Planetary Science
* Mathematics
* Engineering
* Computer Science
* Medical School
* Law School
* Business School

Faculty advisors and instructors in courses will be happy to write letters of recommendation for graduate programs, scholarship opportunities, and fellowships. They will also provide advice on which graduate programs in physics or related subjects will provide the best match with a student's interests.

Most graduate programs in the sciences provide tuition remission and a living stipend in return for work as a teaching assistant or research assistant.

Students who are seeking employment directly from college will find that technical and non-technical positions in many fields are available to physics majors, including:

* Internships and entry-level positions with major corporations
* Computer-related jobs including programming, system administration, and hardware and software maintenance
* Laboratory jobs in industry, hospitals, and universities
* Teaching positions in public and private schools; your major advisor can provide advice on teacher certification

Whatever your plans, physics department faculty members will be happy to discuss them with you and provide guidance and support. The American Institute of Physics provides useful information in its publications and reports, as well as on its web site. The College of Arts and Sciences, through its Career Center, also provides information, support and advice, http://www.aip.org/statistics/trends/careers.html

Courses available 08-09

Courses that are relevant for the Physics Major and are taught this academic year, are listed in the following tables. Each course is offered either in the fall or spring. From this table together with the information provided in this handbook it should be possible to put a complete program together that fits your needs and interests.

Fall Semester 2008

Course No	Course Name
Phys 117A	General Physics I
Phys 197	Physics I
Phys 217	Intro to Quantum Physics I
Phys 321	Electronics
Phys 355	Physics of the Vision
Phys 360	Biophysics Lab

Phys 421	Electricity & Magnetism I
Phys 451	Advanced Lab I
Phys 455	Physics of Vision
Phys 463	Stat Mech & Thermodynamics
Phys 471	Quantum Mechanics I
Phys 482	Research Seminar

Spring Semester 2009

Course No	Course Name
Phys 118A	General Physics II
Phys 198	Physics II
Phys 216	Intro Relativity
Phys 312	Intro to Astrophysics
Phys 314	Physics of the Heart
Phys 316	Optics Lab
Phys 318	Intro to Quantum Physics II
Phys 322/452	Phys Measurements Lab/Adv Lab II
Phys 411	Mechanics
Phys 422	Electricity & Magnetism II
Phys 452	Advance Lab II
Phys 474	Intro to Particle Physics
Phys 478	Black Holes to Big Bang

The Department offers several courses that do not form part of the major requirements. These include for the academic year 08/09:

Fall Semester 2008

Phys 101	Basic Physical Science
Phys 125A	Solar System
Phys 171	Physics and Society

Spring Semester 2009

Phys 110A	Awesome Ideas in Physics
Phys 126A	Stars, Galaxies, Cosmology
Phys 210A	Epic of Evolution

Although mostly non-science majors take these courses, there is enough interesting material in Phys 125, 126, and 171 to warrant attention from science

majors. Phys 171A is also cross-listed as Environmental Studies 272A, and Phys 210A is also cross-listed as Biol 210A and EPSc 210A.

Teaching & Research Faculty

Current active teaching faculty in the physics department are listed below. The list includes e-mail address, phone, office number, as well as websites when appropriate.

Mark G. Alford	Associate Professor, Ph.D., Harvard Univ., 1990 Theoretical particle physics alford@wuphys; x-5-5034; Compton 358 http://wuphys.wustl.edu/Fac/alfordMark.html
Carl M. Bender	Professor, Ph.D., Harvard University, 1969 Theoretical physics; mathematical physics; particle physics cmb@wuphys; x5-6216; Compton 360 http://www.physics.wustl.edu/~cmb/
Claude W. Bernard	Professor, Ph.D., Harvard University, 1976 Theoretical physics; particle physics; computational physics cb@lump; x5-6280; Compton 367 http://www.physics.wustl.edu/~cb/
Thomas J. Bernatowicz	Professor, Ph.D., Washington U., 1980 Mass spectrometry; TEM tom@wuphys; x5-6274; Compton 468 http://www.physics/mcdonnell/bernatowicz.html
James H. Buckley	Professor, Univ. of Chicago, 1994 Cosmic-ray astrophysics; TeV-gamma-ray Astrophysics buckley@wuphys; x5-7607; Compton 253

Anders E. Carlsson	Professor, Ph.D., Harvard University, 1983 Condensed matter theory; materials theory; Biophysics aec@wuphys; x5-5739; Compton 370 http://www.physics.wustl.edu/~aec/
John W. Clark	Professor, Ph.D., Washington University, 1962 Theoretical physics and astrophysics; many-body Theory jwc@wuphys; x5-6208; Compton 351 http://www.physics/mcdonnell/clark.html
Mark S. Conradi	Professor, Ph.D., Washington University, 1977 Experimental condensed matter physics; Magnetic resonance imaging of human beings msc@wuphys; x5-6418, x5-6292; Compton 372 http://www.physics.wustl.edu/~msc/
Ramanath Cowsik	Professor, Ph.D.,University of Bombay, 1968 Theoretical and observational astrophysics, and experimental tests of fundamental physics cowsik@wuphys; x5-4493, Compton 473 http://wuphys.wustl.edu/Fac/Cowsik.html
Willem H. Dickhoff	Professor, Ph.D., Free University Amsterdam, 1981 Theoretical physics; many-particle theory wimd@wuphys; x5-4169; Compton 371 http://www.physics.wustl.edu/~wimd/
Francesc Ferrer	Assistant Professor, Ph.D., Univ. Autònoma Barcelona, 2001 Theoretcial cosmology and astroparticle physics ferrer@physics; x5-7982; Compton 368
Patrick C. Gibbons	Professor, Ph.D., Harvard University, 1971 Solid-state physics, electron scattering pcg@wuphys; x5-6271; Compton 366 http://www.physics.wustl.edu/~pcg/

Charles M. Hohenberg	Professor, Ph.D., Univ. California-Berkeley, 1968 Experimental space science; astrophysics; rare gas mass spectroscopy cmh@wuphys; x5-6266, x5-6257; Compton 451 http://www.physics/mcdonnell/hohenberg.html
Martin H. Israel	Professor,Ph.D.,California Institute Technology, 1968 Cosmic ray astrophysics mhi@wuphys; x5-6263; Compton 250 http://wuphys.wustl.edu/Fac/Israel.html
Jonathan I. Katz	Professor, Ph.D., Cornell University, 1973 Theoretical astrophysics; applied physics katz@wuphys; x5-6202; Compton 267 http://www.physics.wustl.edu/~katz/
Kenneth F. Kelton	Professor, Chair, Ph.D., Harvard University, 1983 Experimental solid state physics and materials science kfk@wuphys; x5-6228, x5-4654; Compton 354 http://www.physics.wustl.edu/~kfk/
Henric Krawczynski	Associate Professor, PhD., Hamburg University (Germany), Experimental High Energy Astrophysics, krawcz@wuphys, x5-8553, Compton 254, http://www.physics.wustl.edu/~krawcz/
James G. Miller	Professor, Ph.D., Washington University, 1970 Ultrasonics; biomedical physics; elastic properties of inhomogeneous media jgm@wuphys; x5-6229; Compton 169 http://128.252.125.77/Personnel/JGM/jgm.html
Zohar Nussinov	Assistant Professor, Ph.D., UCLA, 2000, Condensed matter physics zohar@wuphys; x5-6272: Compton 353

Michael C. Ogilvie	Professor, Ph.D., Brown University, 1980 Quantum field theory and particle physics; theoretical physics; mathematical physics mco@morgan; x5-6256; Compton 356 http://www.physics.wustl.edu/~mco/
James S. Schilling	Professor, Ph.D., University of Wisconsin, 1969 Experimental solid state physics; high-pressure physics schill@wuphys; x5-6239; Crow 215 http://www.physics.wustl.edu/~schill/
Alexander Seidel	Assistant Professor, Ph.D. Massachusetts Institute of Technology, 2003 Condensed matter theory, strongly correlated systems seidel@physics; x5-8933; Compton 355
Stuart A. Solin	Charles M. Hohenberg Professor, Ph. D., Purdue University, 1969 Experimental solid state physics and materials science solin@wuphys; x5-5605;Crow 209 http://www.physics.wustl.edu/~solin/
Wai-Mo Suen	Professor, Cal Inst Technology, 1985 General relativity; cosmology; theoretical astrophysics wms@wuphys; x5-5843; Compton 373 http://wugrav.wustl.edu/People/SUEN/HOME.html
Rebecca L. Trousil	Senior Lecturer, Ph. D., Washington University, 2002 Ultrasonics; Biomedical Physics; trousil@wustl.edu; x5-4495; Crow 214
Yan Mei Wang	Assistant Professor, Ph.D., Univ. of California 2002 Experimental biophysics; single-molecule imaging ymwang@wuphys; x5-7478; Crow 213
Ralf Wessel	Associate Professor, Ph.D., Univ. of Cambridge, 1992 Biophysics rw@wuphys; x5-7976; Crow 216 http://wuphys.wustl.edu/Fac/Wessel.html

Clifford M. Will	Professor, Ph.D., Cal Inst Technology, 1971 Theoretical astrophysics; general relativity cmw@wuphys; x5-6244; Compton 375 http://wugrav.wustl.edu/People/CLIFF/

Research Faculty

W. Robert Binns	Research Professor, Ph.D., Colorado State U., 1969 Astrophysics; medical and health physics wrb@wuphys; x5-6247, x5-8553; Compton 252 http://www.physics/mcdonnell/binns.html
Christine Floss	Research Associate Professor, Ph.D. Wash U. 1991 Space physics; cosmochemistry floss@wuphys.wustl.edu; x5-6206; Compton 456
Mark Holland	Research Associate Professor, Ph.D., Wash.U., 1989 Ultrasound physics; medical ultrasound mrh@wuphys.wustl.edu; x5-6402; Compton 51
Daniel J. Leopold	Research Associate Professor, Ph.D., Wash.U., 1983 Semi-conductor physics; electro-optics; materials science; magnetic resonance leopold@wuphys; x5-6277; Crow 118
Alex Meshik	Research Professor, Ph.D., Vernadsky Institute Moscow, 1988 Space Physics; rare-gas mass spectrometry am@wuphys.wustl.edu; x5-5049; Compton 455
Ernst Zinner	Research Professor,Ph. D., Washington Univ., 1972 Experimental space science; extraterrestrial materials; astrophysics ekz@wuphys; x5-6240; Compton 453 http://www.physics/mcdonnell/zinner.html

Joint Professors

Lee G. Sobotka	Professor (Chemistry); Ph.D.; Berkeley, 1982 Nuclear physics

	lgs@wuchem; x5-5360; Radiochemistry 259
Shankar Sastry	Professor (Mechanical Engineering); Toronto, 1974 Materials science; metallurgy smls@mecf; x5-4869; Jolley 305

Staff

Biondo, Anthony	Machine shop, x5-6209, Compton 143, amb@wuphys
Cisneros, Trecia	Accounting, x5-8155, Compton 244, trecia@physics
Crone, Stanley	Course demonstrations, x5-6255, Crow 202, stan@wuphys
Coffin, Linda	Secretary 4th floor Compton, x5-6257, Compton 458, lcoffin@physics
Devine, Tammy	Accounting, x5-6259, Compton 244, tdevine@physic
Hall,David	Academic/Business administrator, x5-6281, Compton 244A, dhall@physics
Hamilton, Julia	Secretary graduate program, x5-6250, Compton 242, jmh@wuphys
Handley, Scott	Advance lab coordinator & Webmaster, x5-6261, Compton 167, smh@wuphys
Hardt, Todd	Machine shop supervisor, x5-6209, Compton 143, tah@wuphys
Hedley, Sarah	Secretary undergraduate program, x-5-6276, Compton 242, sarahj@wuphys
Huelsman, Denny	Machine shop, x5-6209, Compton 143, dmh@wuphys
Iyer, Sai	Computing, x5-8212, Compton 352A, sai@wugrav
Means, Marla	Executive Secretary to Prof. S.A. Solin, x5-9305
Monteith, Christine	Accountant, x5-6218, Compton 244, christin@wuphys
Poli, Bob	Introductory Physics lab coordinator, x-5-6286, Crow 307
Schmaeng, Rich	Computer support, x5-6294, Compton 140,ras@wuphys
Verbeck, Alison	Librarian, x5-6215, Compton 340, alison@wustl

Physics Office	Compton 242; x5-6276
Observatory	Crow 501; x5-6278
Library	Compton 340; x5-6215
Fax	x5-6219

Security

Access to Compton and Crow after hours is controlled by a magnetic pass card system. Physics majors with proper authorization from their faculty advisors may be added to the Access List in the Department Office (Compton 242). Access to the library outside of regular working hours and to Crow 302, 303, and 305 at all times is controlled by a magnetic pass card system that records the entrant's name. Authorization is provided by the Physics Librarian.

Observatory

The Washington University Observatory houses an historic six-inch reflector and is located on the top of Crow Hall. The observatory is open for general viewing, 7 – 10 p.m., every clear weeknight, and is closed over the weekend. (During those months with daylight savings time, opening is delayed until 8 p.m.) Access is through the south door of Crow Hall, following the signs up through the 4^{th} floor. With the urban atmosphere and the modest size of our telescope, viewing is best for the Moon, planets and the brightest stars. For information or to arrange for a group visit, call (314) 935-6250. At night call (314) 935-6278.