

**HANDBOOK FOR UNDERGRADUATE PHYSICS and  
ASTRONOMY MAJORS**

By

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Louisville, Kentucky

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# CHAPTER I

## INTRODUCTION

### A About This Document

This is edition 1.14 of the Undergraduate Handbook for Physics and Astronomy Majors and Atmospheric Science Majors, updated in July of 2016. It will be updated approximately once each year. As this document is a constantly evolving one, not all sections are complete. Errors of all types should be pointed out to the main author, preferably via email to *david.brown(at)louisville.edu*. Suggestions or submissions of additions are welcome.

A copy of this document should be provided to each new Physics Major in hopes that it will help orient the student to life in the University and in the department. We want to help the student get the most out of his or her experience here. If you are a major and do not have a copy of your own, please contact the departmental office. Note that it should be available via the departmental web page, under “Student Links.”

Here are sections that we would like to see added to future versions of this document (volunteer writers welcome!):

1. General advice for students
2. letters of recommendation
3. Career information and resources
4. Research ethics
5. Research safety
6. What to do in case of troubles
7. The University Honors Program and scholarship opportunities

**B UofL Physics Quick Facts Reference Page****Mail Address:**

<Name: >

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102 Natural Science Building  
University of Louisville  
Louisville, KY 40292

**Office Phone Number:**

502-852-6790

**Office FAX Number:**

502-852-0742

**Department Chair:**

Professor Chakram S. Jayanthi  
102 C Natural Science Building  
502-852-6790

**Graduate Program Director:**

Professor Christopher L. Davis  
205 Natural Science Building  
502-852-0852

**Undergraduate Program Director:**

Professor David N. Brown  
204 Natural Science Building  
502-852-6790

## **C What Physics Is**

Physics is the fundamental scientific study of how nature works. Using the Scientific Method and armed with Mathematics, Computers, Measuring Devices, and Determination, Physicists attack problems from the sub-atomic scale to the scale of the Universe!

Physics underlies and encompasses all of Chemistry, Biology, Meteorology, and Engineering. Instruments developed by Physicists are readily appropriated for use in medicine, industry, defense, and the natural and social sciences.

## **D Why Study Physics?**

Physics is the mathematical and philosophical basis for most natural science and engineering. Therefore, the greater your understanding of physics, the more readily you'll be able to adapt to any scientific problem or situation that arises throughout virtually any career. Moreover, a physics student develops highly sophisticated problem-solving skills for a wide variety of problems. He or she gains the ability to analyze and solve concrete problems with abstract mathematical knowledge.

As a result, many find that a degree in physics opens the door to a large number of career choices in industry, government, and academia. It is a common misconception that people who study physics can only conduct research or teach physics. It is true that the majors that really love the art of physics tend to want to use their talent in the scientific research community and to teach others about it. However, according to the American Physical Society, about 70 percent of all physics bachelor's either enter the industrial workforce or use their talent to pursue careers in fields like engineering, mathematics, chemistry, business, computer science, medicine, or law. Further, it is not uncommon to see physics graduates enter fields such as philosophy, social work, or even finance.

The world is continually changing. Physics equips you with the tools to adapt to a changing world.

## **E About Our Department**

The University of Louisville Department of Physics and Astronomy is a research-active department which offers the Bachelor of Science (BS), Bachelor of Arts (BA), Master of Science (MS), and Ph.D. degrees in Physics, as well as the BS in Atmospheric Science (AKA Meteorology).

All of our faculty hold the Ph.D. in Physics or a closely related discipline and all have acquired considerable research experience before coming to UofL. One of our faculty members (Dr. Kielkopf) received an undergraduate degree at UofL.

## 1 Faculty Directory

The following are faculty members in the UofL Department of Physics as of July 2016. All phone numbers listed are in the 502 area code and the 852 exchange; emails are in the *louisville.edu* domain unless otherwise indicated. Offices are housed in the Natural Science Building (NS), the Schumaker Research Building (SRB), and Ernst Hall (EH). All of our faculty members hold the Ph.D. Professional, full-time faculty have three ranks: *Assistant* Professor, *Associate* Professor, and Professor. New faculty generally start at the Assistant Professor rank and are eligible for consideration for promotion after 6 years. Our faculty typically receive tenure when they are promoted to Associate Professor. Promotion to full Professor rank happens typically after 6 years or more as an Associate Professor, contingent upon the faculty member being recognized as superior in research, teaching, or service. Faculty members who are visiting or serving for a limited contract period are known as Term Faculty.

Faculty Member	Office/Lab	Phone	Email
Swagato Banerjee	NS 210	0915	swagato.banerjee
David N. Brown	NS 204/017	6790	david.brown
Raymond Chastain	NS 135	2918	raymond.chastain
Chris L. Davis	NS 205	0852	C.L.Davis
Tim E. Dowling	NS 201/119	3927	tedowl01
Jian Du-Caines	NS 202	0919	j0duca01
Byron Freelon	NS 211	6790	xxxx
Benne Holwerda	NS 133	6790	xxxx
C.S. Jayanthi (Chair)	NS 102/SRB 243	6790	csjaya01
John F. Kielkopf	NS 001/006	5990	kielkopf
James T. Lauroesch	NS 203	1394	jtlaur01
Shudun Liu	NS 209	0930	s0liu001
Sergio B. Mendes	SRB 240/211	0908	sbmend01
John C. Morrison	NS 200	0916	jcmorr01
Serban Smadici	NS LL003	0853	serban.smadici
Gamini Sumanasekera	EH 314	1558	gusuma01
Gerard M. Williger	NS 206	0821	gmwill06
Ming Yu	SRB 242	0931	m0yu0005

The most recent faculty additions have been Drs. Smadici and Chastain in 2013, Dr. Banerjee in 2015, and Drs. Freelon and Holwerda in 2016.

*Emeritus* faculty are Professors who have retired. Emeritus faculty frequently remain active in the department, maintaining a presence in the classroom and at



colloquia. Here is a current list, as of August 2013, of UofL Emeriti in Physics. Each of our Emeritus faculty members holds the Ph.D.

Emeritus Faculty
Joseph S. Chalmers
Wei-Feng Huang
Roger E. Mills
P.J. Ouseph
John J. Sinai
Shi-Yu Wu

*Adjunct* faculty are professors who hold joint appointments at UofL and another institution – academic or otherwise.

Adjunct Faculty	Office/Lab	Phone
Frank O. Clark	006	5990
Lutz Haberzettl	NS 137	1986
Victor Henner	310	0855

## 2 Staff Directory

The Physics Staff play a very important role in the functioning of the department. This is a list of the staff as of July 2016.

Staff Member	Office	Phone	Position
Rick Crume	Chem bld.		Sci. Instrument Spec.
Rea Diehlman	NS 105	6790	Unit Business Mgr.
Joel Evans	NS 223	442-9523	Computer Support Spec.
Lutz Haberzettl	NS 137	1986	Linux Sysadmin
Joshua Rimmer	NS 002	0065	Instruments Tech Sr.
Tatyana Tarakanova	NS 307	0933	Lab Coordinator
Mary Gayle Wrocklage	NS 102	6790	Administrative Asst.

When you enter the Physics Office in room 102 of the Natural Sciences Building, Mary Gayle is the person most likely to greet you, or one of the work-study student assistants.

### 3 Departmental Research

Research is the key to understanding. Experimental physicists typically investigate nature by observing phenomena with intelligently designed equipment and making careful measurements of their observations. They hope to discover new phenomena or verify a certain prediction. Theoretical Physicists typically develop models and theories and use computers to predict new phenomena or to verify experimental results. Theoreticians and experimentalists complement each other as they strive to understand the complex world around us.

Faculty in our physics department are involved in a broad spectrum of research activity, both theoretical and experimental. We have faculty conducting research in Astrophysics, Atmospheric Science, Atomic and Molecular Physics, Condensed Matter Physics, and High Energy Physics. All of our faculty have tremendous research experience, produce many prestigious publications, and present their work at professional meetings. Several faculty members' research is well known nationally and internationally. Please visit <http://www.physics.louisville.edu/research.html> for more detailed information about each research area and links to specific faculty research web pages.

Note that as a part of our research mission, the department maintains the University's Moore Observatory, located in Oldham County. We also maintain the Mt. Kent Observatory near Toowoomba, Australia, in conjunction with the University of South Queensland. Members of the department also maintain strong working relations with major research facilities such as Oak Ridge National Lab, NASA labs, FermiLab, and the SLAC National Accelerator Laboratory.

Undergraduate students are encouraged to read the information on the web about the research groups in our department, to talk to the faculty leading the research, and to get involved with a group that seems exciting. Undergraduate research can be a very fun and rewarding experience while working toward your degree. It will also give you an edge above the average student when applying for a job or competing to get into a specific graduate school. While most undergraduate research is performed as voluntary service, some research groups are able to pay for part-time undergraduate research assistants.

### 4 Brief History of the Department

The Department of Physics at the University of Louisville has existed in several forms over many years. We know that classes in Physics have been offered here since at least the first decade of the 20th century. At that time, the classes were offered downtown. In 1925, Physics classes moved from the second floor of a "barn" near the corner of 2nd and Broadway to the Belknap Campus. During the first half of the 20th century, two Physics Departments developed independently: one in the Speed School and one in the College of Arts & Sciences. These

departments eventually merged in the 1960s to form the department we know today.

## 5 Departmental Facilities

The Department maintains several facilities worth note to students. First is the Physics Learning Center (PLC), located on the ground floor of the Miller Information Technology Center. This is a convenient location to sit and study or to receive tutoring.

As of January 2016, a Technology Enhanced Active Learning (TEAL) room is available at the east end of the first floor of the Natural Science Building. This room provides multiple computer workstations, whiteboards, and monitors in a setup designed to encourage active learning in the classroom. It also facilitates Physics Education Research by faculty members, helping to improve the efficacy of our teaching methods. A student computing room, boasting 6 Linux computers in a cluster, is located in NS 132, adjacent to the TEAL room. It is used mainly by students in PHYS 565, though use in other circumstances can be arranged.

In the basement, in NS LL018, is the office of the local chapter of the Society of Physics Students (SPS). Students are also welcome to hang out there.

The department's main conference room and location for weekly SPS meetings is "The Adams Room," NS 104. The room is named for former Department Chair Carl Adams.

On the third floor, in room 327, we have "The Dillon Room." Named for the late Dr. John Dillon, who held many important offices within the University, this room serves as a study/reflection/discussion lounge. It is a comfortable environment in which to relax and find a good book. You have to be allowed into the room by someone with a key.

The Moore Observatory, in Oldham County, is named for former UofL Professor Dr. Fred Moore and is maintained by the department. Occasionally, we will have outings to the observatory.

The Rauch Planetarium is maintained by the College of Education and Human Development, but has close historical ties to this department. Our department has shaped much of the academic direction of the Planetarium, as we use it for both teaching and outreach to the community.

## CHAPTER II

### PROGRAMS OF STUDY

The Department of Physics & Astronomy is part of the College of Arts & Sciences at UofL. For undergraduates, we offer the BS and BA degrees and a Minor in Physics. The BS and BA are described here in full, with program requirements taken directly from the University Catalog. We also include brief descriptions of our graduate degrees for your information. Of particular interest in this area may be the 5-year plan for obtaining a BS and MS in Physics.

Note that credit requirements given are the minimum required for the degree. There is no penalty for getting more credits, up to 60 in the major field of study. Over 60 credits in the field the hours no longer count toward the degree. We do encourage you to take more than the required number of credit hours in Physics - this is where University electives can be used.

Please note that the Department sets the course requirements for these degrees. This means that the Department also controls variations on the programs listed below. **If you encounter difficulty fitting the required courses into your program, the Undergraduate Program Director can work with you to find a mutually satisfactory replacement, or a similar solution.** As the Hitchhiker's Guide to the Galaxy says: "Don't Panic!"

#### A The Bachelor of Science Degree

The B.S. Degree is intended as preparation for entry into graduate programs in Physics and other scientific or engineering fields. It also provides suitable training for entering the workforce in a technical position.

	Semester Hours	Total
<b>General Education</b> .....		<b>34</b>
All degrees require the completion of the University-wide General Education Program; see the online catalog for the General Education requirements and the courses which fulfill them. Some General Education requirements may be met in the requirements for the major or supporting coursework, in which case additional electives may be required to complete the minimum hours for the degree.		
<b>Arts &amp; Sciences Programmatic Requirements</b> .....		<b>13-15</b>
General 101: A& S Orientation .....	1	
Foreign Language (completion of the second semester of a single foreign language; hours will vary depending on the language taken) .....	6-8	
Electives in Humanities or Social Sciences at the 300 level or above, in addition to courses counted toward General Education .....	6	

WR-two approved courses at the 300 level or above (may be incorporated into other degree requirements).

**Department of Physics ..... 42-44**

Core Courses

Physics 295<sup>1</sup> or 295H<sup>1</sup>, 296 or 296H, 301 ..... 3

Physics 298<sup>1</sup> or 298H<sup>1</sup>, 299 or 299H, 300 ..... 11

Physics 351 ..... 2

Physics 350, 450, 460, 530, 541, 555 ..... 19

Professional, Applied, or Astronomy and Astrophysics concentration (see below)

9-10

**Physics Concentrations**

**Professional ..... 9**

Physics 542 ..... 3

Physics 556 ..... 3

Physics 498 ..... 3

**Applied ..... 9-10**

One of Physics 308, 356, 546 ..... 1-2

One of Physics 542, 545, 547, 556, 565, 570, 575, 580, 585, 589, 590 ..... 3

Physics electives at 300 level or above ..... 4-5

Note: Alternate choices within or outside department are possible with approval

**Astronomy and Astrophysics ..... 10**

Physics 307 ..... 3

Physics 308 ..... 1

Physics 355 ..... 3

Physics 590 ..... 3

**Supporting Courses ..... 18**

Chemistry 201 and 202<sup>1</sup> ..... 6

Mathematics 205<sup>1</sup>, 206, 301 ..... 12

**Minimum Electives ..... 9-14**

**Minimum Total ..... 121**

Only 60 hours in the major department may be applied toward the Bachelor of Science degree. At least 50 of the total minimum hours required must be at the 300 level or above.

<sup>1</sup>Fulfills general education requirement.

## B The Bachelor of Arts Degree

The B.A. degree in Physics is designed for substantial pre-professional education for such fields as medicine, patent law, teaching, technical writing, and technical sales. Students preparing for secondary school science teaching may choose electives to fulfill teaching certification requirements and, if desired, to complete a 21-hour teaching minor.

	Semester Hours Total
<b>General Education</b> .....	<b>34</b>
All degrees require the completion of the University-wide General Education Program; see the online catalog for the General Education requirements and the courses which fulfill them. Some General Education requirements may be met in the requirements for the major or supporting coursework, in which case additional electives may be required to complete the minimum hours for the degree.	
<b>Arts &amp; Sciences Programmatic Requirements</b> .....	<b>22</b>
General 101: Modes of Inquiry .....	1
Foreign Language .....	12
Electives in Humanities or Social Sciences (in addition to courses counted toward General Education, 6 credit hours must be at the 300 level or above) .....	9
WR-two approved courses at the 300 level or above (may be incorporated into other degree requirements).	
<b>Department of Physics</b> .....	<b>32</b>
Physics 295 <sup>1</sup> or 295H <sup>1</sup> , 296 or 296H, 301 .....	3
Physics 298 <sup>1</sup> or 298H <sup>1</sup> , 299 or 299H, 300 .....	11
Physics 460, 530, 541 .....	9
Physics electives at the 300 level or above .....	9
<b>Supporting Courses</b> .....	<b>29</b>
Mathematics 205 <sup>1</sup> , 206, 301 .....	12
Chemistry 201, 202, 207, 208, and 209 .....	9
Biology 240 and 244 .....	5
Geosciences 301 .....	3
<b>Minimum Electives</b> .....	<b>3</b>
<b>Minimum Total</b> .....	<b>121</b>

## C The Master of Science Degree

Information in this section is taken directly from the Graduate School web page (<http://louisville.edu/graduatecatalog/>).

Departmental requirements for admission to the MS program are as follows:

1. A baccalaureate degree with at least 24 hours in physics, or the equivalent.
2. A minimum quality-point standing of 3.0 (base 4.0) in physics courses.
3. Mathematics course work through differential equations. (MATH 405 or equivalent)
4. Submission of the Graduate Record Examination scores.

General requirements for the M.S. degree are set forth in the General Information section of the Graduate catalog. For the M.S. degree, 30 hours are required, of which at least 21 hours must be in courses open to graduates only (typically 600 level and above).

Specific requirements for the M.S. degree in physics are as follows:

### **Thesis option: (30 credit hours)**

1. Required courses in physics (12 hours):

605, Theoretical Mechanics (3);  
611, Electromagnetic Theory I (3);  
621-622, Quantum Mechanics I & II (6).

2. Physics electives (6-9 hours): courses numbered 500 and above.
3. Courses in one minor field (3-9 hours): Mathematics is the usual minor, but another field may be chosen with the approval of the department.
4. Graduate Research and Thesis(6 hours).

### **Non-thesis option: (33)**

1. Required courses in physics (12 hours):

605, Theoretical Mechanics (3);  
611, Electromagnetic Theory I (3);  
621-622, Quantum Mechanics I & II (6).

2. Physics electives (12 hours): courses numbered 500 and above.

3. Courses in one minor field (3-9 hours): Mathematics is the usual minor, but another field may be chosen with the approval of the department.
4. Graduate Research (0-3 hours).
5. At least 17 credit hours numbered 600 and above.

#### **D The Five-Year BS/MS Degree Program**

The department has a five-year program leading to the BS and MS degrees in Physics. This is the text of the program, taken from the Graduate School Catalog: The Department of Physics & Astronomy offers a 5-year accelerated program leading to a Bachelor of Science degree and Master of Science degree in Physics. Departmental Requirements for admission are:

1. Student will apply for admission to the 5-year accelerated program in the second semester of his or her junior year.
2. Student will have completed at least 21 credit hours in Physics before applying for the program.
3. Student will have maintained at least a 3.0 GPA in Physics courses, and a 3.35 GPA overall.

Once accepted, the student will have to meet the following requirements:

1. Submit GRE General Test Score consistent with Graduate School guidelines.
2. Take at least nine (9) credit hours in 500-level Physics courses for graduate credit. Two of the courses must be PHYS 542 and PHYS 556. Preferably, these courses will all be taken during the same semester during the student's senior year.
3. Maintain a 3.0 GPA.

The undergraduate portion of this degree has an identical distribution of non-physics requirements as the standard Professional track BS in Physics.

Undergraduate Physics Requirements for the 5-year program in Physics:

PHYS 298 or 298H .....	4
PHYS 299 or 299H .....	4
PHYS 295 or 295H .....	1
PHYS 296 or 296H .....	1
PHYS 300 .....	3
PHYS 301 .....	1



PHYS 390 and 450 .....	6
PHYS 460, 541, and 555 .....	9
PHYS 498 .....	3
<b>Total .....</b>	<b>34</b>

Graduate Requirements for the 5-year BS/MS program in Physics:

**Thesis option: (30 credit hours)**

1. Required Courses in Physics (18 hours):
  - (a) PHYS 542 and PHYS 556
  - (b) PHYS 605, PHYS 611, PHYS 621, and PHYS 622
2. Physics electives (0-3 hours): courses numbered 500 and above
3. Courses in one minor field (3-9 hours): Mathematics is the usual minor, but another field may be chosen with the approval of the department.
4. Graduate Research (6 hours).

**Non-thesis option: (33 credit hours)**

1. Required courses in physics (18 hours):
  - (a) PHYS 542 and PHYS 556
  - (b) PHYS 605, PHYS 611, PHYS 621, PHYS 622
2. Physics electives (6 hours): courses numbered 500 and above
3. Courses in one minor field (3-9 hours): Mathematics is the usual minor, but another field may be chose with the approval of the department.
4. Graduate Research (0-3 hours).
5. At least 17 credit hours numbered 600 and above.

## **E The Doctorate of Philosophy Degree**

Since 2009, the Department has been offering a Ph.D. in Physics. A complete description of the degree can be found at <http://louisville.edu/graduatecatalog/programs/degree-programs/academic/ga/physphd>.

The degree has course requirements similar to the MS degree, with the addition of Phys 650, Research Methods for Physics and Astronomy. The student is required to pass a qualifying exam before moving into candidacy, and to complete a dissertation to the satisfaction of his or her Ph.D. committee.

## F Sample 4-year Physics Course Plan for Undergraduates

Every student enters the University with a different background preparation, work schedule, etc. So it is not possible to provide a course plan suitable for everyone. Here we present two scenarios developed *within* the Department. Since we first developed these plans, the University has developed its own system of advising plans, known as “flight plans.” You can access the University’s official flight plans at <http://louisville.edu/flightplan>.

Here are the scenarios for which we provide sample course plans:

1. A student who enters the University as a freshman, ready to take Calculus, pursuing a BS along the Professional Track.
2. A student who enters the University ready to take College Algebra, pursuing a BS along the Astronomy and Astrophysics Track.

In both cases, we recommend completion of Calculus I before beginning PHYS 298, though this is not officially required. It is worth note that by taking the minimum 12 credit hour full-time load in only the Fall and Spring semesters, one will not be able to graduate in 4 years. On average, you should take 14.5 credit hours per semester or plan on taking some summer classes (early on) in order to graduate in 4 years (a worthwhile goal!).

For the student in the first scenario, a four-year plan might look like this:

Year	Fall	Spring	Summer
Freshman	Calc I (4) GenEd/ electives (9)  13 cr	Calc II (4) Phys 298 (4) Phys 295 (1) GE/elect (3-6) 12-15 cr	0 cr
Sophomore	Calc III (4) Phys 299 (4) Phys 296 (1) GE/elect (3-6) 12-15 cr	Phys 300 (3) Phys 351 (2) Phys 350 (4) GE/elect (6-9) 15-18 cr	Phys 498 (3) and GE/elec (3) or REU  0-6 cr
Junior	Phys 301 (1) Phys 450 (3) Phys 541 (3) GE/elect (6-9) 13-16 cr	Phys 460 (3) Phys 530 (3) Phys 542 (3) GE/elect (3-6) 12-15 cr	Phys 498 and GE/elec (3) or REU  0-6 cr
Senior	Phys 555 (3) Phys elec (3) GE/elect (6-9)  12-15 cr	Phys 556 (3) Phys elec (3) GE/elect (6-9)  12-15 cr	Graduated

Total credit hours: 99 (taking the minimum credit hours listed per semester - NOT ENOUGH TO GRADUATE) to 129 (taking the maximum credit hours listed per semester - easily giving enough to graduate). The GE/elect shown in the table above is used to represent General Education, University elective, programmatic requirement, and programmatic elective courses. Note that you should choose electives in such a way that at least 50 credit hours are at the 300 level or above.

In scenario 2, the four year course plan might look like this:

Year	Fall	Spring	Summer
Freshman	Math 111 (3) GenEd/ electives (9)  12 cr	Math 112/190 (3-4) Phys 111 (4) GE/elect (3-6)  10-14 cr	GE/elect (3-6)   3-6 cr
Sophomore	Calc I (4) Phys 298 (4) Phys 295 (1) GE/elect (3-6) 12-15 cr	Phys 299 (4) Phys 296 (1) Calc II (4) GE/elect (3-6) 12-15 cr	Phys 501 (3) and Calc III (3) or REU  0-6 cr
Junior	Phys 300/301 (4) Phys 355/356 (5) Phys 308 (1) GE/elect (3-6) 13-16 cr	Phys 450 (3) Phys 307 (3) GE/elect (6-12)  12-18 cr	Phys 501 (3) and GE/elec (3) or REU  0-6 cr
Senior	Phys 460 (3) Phys 541 (3) Phys 555 (3) Phys 590 (3) 12 cr	Phys 589 (3) Phys elec (3) GE/elect (6-9)  12-15 cr	    Graduated

Following this curriculum would give you at a minimum 98 credit hours (not sufficient to graduate!) and a maximum of 129 credit hours (sufficient to graduate).

Remember, these are just SAMPLES. Real schedules will vary. See your advisor - the Undergraduate Program Director (Dr. David N. Brown) to help find the schedule that works best for you. If you fear that you won't be able to finish your degree in time because a class isn't offered when you need it - well, don't panic! Go see the Undergraduate Program Director. You may well find that there are options to help you out.

## G BS in Atmospheric Science

The BS in Atmospheric Science complies with Government Standard 1340 for a meteorology degree. With this degree, one is qualified to work at the National Weather Service or to pursue graduate education in meteorology.

	Semester Hours Total
<b>General Education</b> .....	<b>34</b>

All degrees require the completion of the University-wide General Education Program; see the online catalog for the General Education requirements and the courses which fulfill them. Some General Education requirements may be met in the

requirements for the major or supporting coursework, in which case additional electives may be required to complete the minimum hours for the degree.

**Arts & Sciences Programmatic Requirements . . . . . 13-15**

General 101: A& S Orientation . . . . .	1
Foreign Language (completion of the second semester of a single foreign language; hours will vary depending on the language taken) . . . . .	6-8
Electives in Humanities or Social Sciences at the 300 level or above, in addition to courses counted toward General Education . . . . .	6
WR-two approved courses at the 300 level or above (may be incorporated into other degree requirements).	

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Core Courses	
Physics 295 <sup>1</sup> or 295H <sup>1</sup> , 296 or 296H, 301 . . . . .	3
Physics 298 <sup>1</sup> or 298H <sup>1</sup> , 299 or 299H, 300 . . . . .	11
Atmospheric Science Core	
Physics 220/Geography 220, Physics 360,361, 362, 365, 465, 466, 469	
Geography 355 . . . . .	27

**Supporting Courses . . . . . 25**

Physics 350 . . . . .	4
Mathematics 205 <sup>1</sup> , 206, 301 . . . . .	12

A minimum of 9 hours from the following courses,  
with courses taken in at least two disciplines:

- Civil & Environmental Engineering 470;
- Chemistry 341, 441;
- Geosciences 363, 564;
- Mathematics 560;
- Physics 355, 356, 390, 530, 541, 545, 546

**Minimum Electives . . . . . 6-8**

**Minimum Total . . . . . 121**

Only 60 hours in the major department may be applied toward the Bachelor of Science degree. At least 50 of the total minimum hours required must be at the 300 level or above.

<sup>1</sup>Fulfills general education requirement.

## CHAPTER III

### STUDENT RESOURCES

#### A Computers and Accounts

As a University of Louisville student, you should have been issued an account on the central university systems. This allows you to login to a number of computing systems on campus using a single username (or login ID) and password. The username assigned by the University follows a standard pattern: the first letter of your first name followed by the first letter of your middle name followed by the first four letters of your last name, plus a two-digit number. For example, David Norvil Brown has the username dnbrow01 while Rebecca Faye Duncan has the username rfdunc02. If you don't have a middle name, or if you have fewer than four letters in your last name, the digit 0 will take the place of the missing letters. So for example Shudun Liu has the username s0liu001.

The Physics Department also has its own system of computers. These computers are primarily PCs running the Linux operating system and are located in rooms 132 NS. A printer is also available in this room for printing from the network. These resources are available to all members of the department, though a key is required to enter the room. Students are not automatically issued a key to this room and typically will only work there when they can find someone to let them in. For an account on this system, please see the Department's Linux system administrator.

Additionally, several of our research groups maintain their own computing systems, all of which are independent. Dr. Brown maintains a Linux and Mac cluster for the High Energy Physics group. Drs. Jayanthi and Wu have a very large Linux-based system for the Condensed Matter Theory group. Dr. Kielkopf maintains a Linux cluster for his work in Atomic/Molecular/Astrophysics. Drs. Dowling and Du-Caines maintain a Mac and Linux cluster in the Atmospheric Science Lab. Additionally, there are some groups of Macintosh and/or Windows computers in introductory labs which can be used on occasion under supervision.

**Specific Recommendations.** We recommend that students become familiar with Linux/Unix-based computer systems. We recommend students check email DAILY (preferably twice). We recommend that they learn to use their University-provided email address as primary email account.

For reasons of security, students are advised to use caution with web-based mail accounts or Microsoft Outlook (or most any Microsoft products, for that matter). When choosing passwords, please choose passwords that are at least 8 characters in length and which contain a mixture of uppercase and lowercase letters, numbers, and any of !#\$%&\*(). Do not share your account or password with anyone. It is also preferable that you do not write your password down, or if you

must that you destroy a written password once it has been committed to memory.

## **B Departmental Web Pages**

The main departmental web pages are currently hosted on a Mac OS X server. The web address for the Physics Department home page is:

<http://www.physics.louisville.edu/>

Webmaster for the Physics pages' content is Ollie Hyams, with some input from faculty.

There are two other webservers maintained within the department:

<http://www.hep.louisville.edu/>

is the server for the High Energy Physics group (and friends) and is maintained by Dr. Brown and Ph.D. student, Jamie Bougher.

<http://www.astro.louisville.edu/>

is the server for Astronomy and Astrophysics, maintained by Dr. Kielkopf.

## **C Who To Go To For...**

### **1 Computing Questions**

For computing questions involving University central computing - computers in IT labs, network connections to offsite/dorms, etc. - you should call or email the IT helpdesk. The phone number on campus is 852-7997.

For help with a departmental system, you should contact the Department's Linux system administrator. Dr. Brown, Dr. MacCall, or Dr. Kielkopf can also help sometimes. For help with a research group computer system, you should see the manager of the research group computer, or the Departmental Linux system administrator.

For general programming help, you might contact Drs. Brown, Jayanthi, Kielkopf, Liu, or Sumanasekera. You can also browse the web, read some of the books in the High Energy lab, or consult fellow students. Remember that these are all busy people and be considerate about asking for their time.

### **2 Keys**

Keys are usually obtained from Mary Gayle Wrocklage in room 102 NS. Undergraduates must be approved for a key by a faculty member before they can actually obtain the key from Ms. Wrocklage. Undergraduates will usually only receive a key in the following circumstances: (1) they serve as undergraduate teaching assistant (UTA); (2) they need access to a research lab and have the professor's permission; (3) on very rare occasions, undergraduates may get an outside door key if deemed necessary for after-hours work by a professor.

### 3 Payroll Issues

See Rea Diehlman or Mary Gayle Wrocklage in the Physics & Astronomy Office (room 102/105 NS) to fill out paperwork to be put on the payroll. This will typically only be necessary if you are hired by a professor as a research assistant or if you are hired by the department for teaching. Time sheets should be completed on a daily basis and submitted every other Thursday to Mary Gayle Wrocklage in the Physics & Astronomy office. Problems with a check should be reported to Rea Diehlman immediately.

### 4 Advising

Students have two academic advisors: a general advisor in the A& S Advising Office (Gardiner Hall) and a Physics advisor within the department. Students in the Honors Program can also work with the Honors advisors.

Your Arts & Sciences advisor is located in Gardiner Hall. She can help you with the choice of General Education requirements and most of your non-Physics scheduling, especially in your freshman and sophomore years. She will also perform a degree check before you graduate (you should request a preliminary degree check sometime before your final semester).

Currently, undergraduate advising in Physics is done primarily by the Undergraduate Program Director (UPD). The UPD at this time is Dr. David N. Brown. You should schedule an appointment with the UPD once or twice per semester (once early on and once just before registering for the next semester). The Department Chair can also help with advising when needed.

### 5 Independent Study, Research, Internship

Students wishing to study specific topics beyond or outside our established curriculum may seek a form of independent study. Please see the undergraduate or graduate catalog for information about GPA requirements and a ceiling on the number of independent study courses that can be taken.

**Physics 501 and/or 502 - Independent Study:** This independent study is used to do a “library study” of a topic that is well enough established to appear in a textbook or similar review manuscript. You may want to do an independent study if there is a Physics or Astronomy topic that appeals to you but is not offered in our curriculum, or that is offered but not in time for your graduation. The student is expected to do mainly self-guided work, checking in with a faculty member on a regular basis for guidance.

**Physics 498 - Undergraduate Research:** This independent study is used to do research into a problem that is not already solved, or to attempt a new approach to a recently solved problem. Typically, there is no text that contains the



solution to the problem undertaken. The research topic may originate with the student, but more often, the problem will be assigned by a faculty research mentor and will be closely related to her or his existing research.

**Physics 499 - Cooperative Internship:** While an internship is not required for any of our Physics degree programs, it can provide valuable experience. Students have held internships working with with weather team at a local TV station's news program, working in the medical physics department of a local hospital, and working with a local firm on testing equipment used in environmental monitoring. Students who choose this route are responsible for arranging their own internship and locating a faculty member in Physics & Astronomy who will serve as their departmental sponsor.

**What to do:** Find a faculty member who will agree to work with you. Then come to the Physics office and get an independent study form. You and the faculty member should fill this out together. You should create a 1-paragraph work plan that briefly describes the work to be done and a means for evaluation – *e.g.* homework, a research poster, a paper, exams, etc.

## D Professional Organizations

Most academic disciplines have affiliated professional organizations. The professional organizations help promote the discipline, maintain the integrity of the discipline, and coordinate efforts in the academic area to some degree. Membership in these organizations carries many benefits. Students often can get memberships at greatly reduced rates.

### 1 AIP

The American Institute of Physics (AIP) is the umbrella organization for Physics in the United States. AIP is not a member society - that is, no one becomes a member of the AIP directly, though they may *work* for AIP - but it oversees a number of member societies. It also publishes journals, provides career services for Physicists, and advances the field to the public and politicians. Find the American Institute of Physics online at *www.aip.org*.

### 2 APS

The American Physical Society (APS) is the main member society of the AIP. It consists of over 40,000 members. Members can optionally choose to belong to any of 14 divisions in APS, 6 fora, 9 topical groups, or 8 regional sections. APS publishes some of the most distinguished scientific journals in the world, including the *Physical Reviews*. APS conducts major meetings and conferences each year. The APS March and April meetings are especially known for their high turnout

(thousands of Physicists per meeting). The American Physical Society is online at [www.aps.org](http://www.aps.org).

### 3 AAPT

The American Association of Physics Teachers (AAPT) is another member society under the umbrella of the AIP. AAPT is for those who teach Physics or are interested in the teaching of Physics. AAPT publishes the journals *American Journal of Physics* and *The Physics Teacher*. AAPT also sponsors several meetings and/or conferences each year, including an April meeting joint with the APS. As you might guess, the AAPT is online at [www.aapt.org](http://www.aapt.org).

### 4 KAPT

The Kentucky Association of Physics Teachers (KAPT) is one section of the AAPT.

## E The Society of Physics Students

The Society of Physics Students (SPS) is a professional physics association explicitly designed for students. It exists to help students transform themselves into contributing members of the professional community. Typically the SPS engages in outreach, educational, social, and community service activities to encourage students to develop communication skills, leadership experience, and a personal network of contacts. The SPS regularly makes scholarships and research opportunities available to students. Student researchers may receive support from the SPS to travel to present their scholarly work at professional meetings as well. Typical activities include inviting guest speakers in to talk about research or physics related topics, taking trips to educational sites, such as national laboratories, offering tutoring to students, judging local science fairs, and many more. Students generally find SPS activities very rewarding and entertaining. SPS also spends a lot of time having pure fun by sponsoring picnics, movie marathons, and intramural sports teams.

SPS Membership, through collegiate chapters, is open to anyone interested in physics. Membership has, in recent years, ranged from 10 to 50 people, both graduate and undergraduate, from many different areas of study. Besides physics majors, our members include majors in chemistry, computer science, engineering, geology, mathematics, medicine, and other fields. Approximately 100 students are on our local email distribution list at any given time. Membership dues are typically \$10.00 per semester locally and \$25.00 per year nationally, though the local chapter has been experimenting with special offers on membership lately. You can join SPS at either or both the local and national level. The University of Louisville chapter of SPS meets once every week (usually Fridays at noon) in the physics department.

Please visit our website (see link on department homepage) for more information. You may register for the national Society of Physics Students organization at *www.spsnational.org*.

## **F $\Sigma\Pi\Sigma$ – The Physics Honors Society**

SPS grew out of the  $\Sigma\Pi\Sigma$  Honors Society, but now  $\Sigma\Pi\Sigma$  is the honors branch of SPS. Sigma Pi Sigma membership is open to undergraduate and graduate students as well as faculty members. In general, a candidate for membership must be in the upper one-third of their class in general scholarship to meet the minimum requirements for admission. The candidate must also have completed at least three semesters of full-time college work and at least three semester courses in physics. You must apply for membership in the spring. Details on application will be announced in SPS meetings each spring before the application deadline, so be on the lookout.

## **G The Physics Learning Center**

The Physics Learning Center (PLC), located on the ground floor of the MITC Building, offers students a supportive, but informal, environment to sit and study with a group or alone. An upperclassman in Physics is almost always present for on-the-spot tutoring and help with homework problems. Other things you may find useful in the PLC are: various science texts that may help with studying, physics periodicals to read while taking a break from homework, and marker-boards to sketch out thoughts and discuss problems with others. It is also a great place to review for upcoming exams with a few classmates. The PLC is designed to encourage you to become a successful student, so use it to your advantage!

## CHAPTER IV

### SURVIVAL AND SUCCESS GUIDE

#### A Qualities of the Successful Physics Major

The qualities listed here are not all specific to Physics; many of the qualities that make one a success at Physics are the same as those which make one successful at most anything. Physics pays back these qualities with a rewarding and beautiful study of the world around you and a set of skills which will be useful to you throughout life.

1. **Initiative.**
2. **Hard Work.**
3. **Dependability.**
4. **Honesty and Integrity.**
5. **Mathematical Ability.**
6. **Attention To Detail.**

#### B Getting Involved In The Life Of The Department

One of the best ways to improve the value of your education is to immerse yourself in your program of study. Here are some ways you can immerse yourself in the Department of Physics & Astronomy:

1. **Join SPS.** This is probably the single best way to get involved directly with the department. It provides social and educational interaction and plain old good fun!
2. **Attend colloquia.** While many of the colloquia will be above your head at first, you will begin to get the flavor of modern Physics research.
3. **Attend special events.** On the Tuesday of Thanksgiving week, the Department of Physics holds a Thanksgiving lunch. This is a great opportunity to socialize with other members of the department. This is just one example of a special event held by the department.
4. **Apply to PRIMES.** This National Science Foundation-sponsored program pays undergraduates to train and serve as teaching assistants. Not only is it a great way to earn money while immersing yourself in the life of the

Department, it is also a great way to help you REALLY learn your physics! For more information, see section D.

## C Getting Involved In Research

Students may join a research group in the department through any of three mechanisms: as a volunteer, as a student taking PHYS 498 or 501, or as a paid research assistant.

You can find out about our research by viewing the departmental overview of research, the individual group web pages, and the undergraduate research page. To find out more about a research group, make an appointment to meet with the professor or professors in charge. Typically, students invited to work with our research groups will have a GPA of 3.0 or higher.

One option we recommend for summer research is the National Science Foundation's Research Experience for Undergraduates (REU) program. This is a competitive program which allows you to apply to work with research groups at other universities during the summer. A student receives \$2,500 - \$5,000 for a 10-week program with lodging usually provided free by the host university or lab. To get the latest information, check out the National Science Foundation (NSF) website at <http://www.nsf.gov/crssprgm/reu/>

## D Getting Involved in Teaching with PRIMES – be a UTA!

The University of Louisville received a five-year grant in 2011 from the National Science Foundation for its Program for Retention In Math, Engineering, and Science (PRIMES). The program selects cohorts of undergraduates in Physics and other science and engineering departments, trains them in science education methods, and then pays them to serve as teaching assistants (TAs). You can apply to the program in your Junior year, and may participate for up to three semesters. Dr. Brown is the Departmental contact for the program.

The hope is that you will (1) help younger undergraduates learn better, (2) inspire those students to continue with STEM degrees, (3) improve your own understanding of physics, and (4) improve the learning climate in the Department. As envisioned, it is a win-win-win-win opportunity!