

UNDERGRADUATE PROGRAMS
PHYSICS
MICHIGAN STATE UNIVERSITY

June 2001

A Physics Major as a Preparation for a Career

In an Undergraduate Physics Major a student learns about the physical nature of the universe in which we all live. A major in Physics is not only a strong base for a technical career, it is also an education in the philosophical development of the interpretation of observations of all physical phenomena in a consistent manner. In the course of the four-year program the contributions of great physicists throughout the history of the evolution of the science are discussed together with their relationship to the accepted views of their times. In all these senses physics is a humanistic and liberal arts major in the best sense and helps prepare the student for a culturally fruitful life.

Physics is an excellent career major. The key to a successful career in these changing and unpredictable times is flexibility, namely, the ability to adjust one's career to technological and societal changes. Most of what one learns or achieves in physics is fundamental and enduring. Example are: the processes by which science in general and physics in particular advance; the ability to analyze physical situations in quantitative terms; the mastery of sophisticated mathematical analytical methods; the skills necessary to handle and use a wide variety of measuring instruments; the laws of physics as understood at present; and considerable facility in the use of computers.

These enduring values of the undergraduate physics major not only provide the flexibility to alter one's career one or more times during one's productive life, but also make possible great flexibility in the initial choice of a career.

Many of our physics majors continue their studies upon graduation and go on to graduate work in physics leading to the masters or doctoral degree. This training prepares them for teaching and/or research in Colleges and Universities and for industrial and government research. With many of our Energy and Environmental problems needing solutions involving physics, and with the appearance of new technologies resulting from discoveries in physics, a substantial number of openings will be available. As the 21st Century progresses, it is possible that a shortage of physicists in our society trained at the graduate level will be an acute problem.

Some of our majors go to graduate or professional school in other fields. A few typical examples are Astrophysics, Geophysics, Biophysics, Meteorology, Oceanography, Mathematics, Engineering, Philosophy, Law, Medicine, Business Administration, etc. In each of these areas the physics major provides a useful and unique background which frequently leads to interesting and challenging careers.

The majority take direct employment, a few in the military but most as civilians in industrial laboratories involved in research and development in technological areas. Some enter secondary school teaching where there is a serious shortfall and a continuing need for well-trained teachers in physics, chemistry, physical science, mathematics, and electronics. Other positions involve technical sales, laboratory assistant in optics, optical electronics, materials science, or data analysis with computers, etc. Health Physics is another area which is growing and where a minimum amount of training beyond the bachelors degree can prepare one for a satisfying and productive career. Advanced training in health related areas of physics is also becoming increasingly available.

UNDERGRADUATE PROGRAMS IN PHYSICS

The Department of Physics and Astronomy offers two undergraduate programs to students who have a professional or a cultural interest in this basic science. One leads to the Bachelor of Science degree and the other to the Bachelor of Arts. The B.S. degree program requires more concentration in physics and is designed to prepare the students for graduate work leading to the M.S. and Ph.D. degree with their major in physics, or for junior research positions in industrial laboratories. The B.A. program is constructed primarily for those students who desire less specialization in physics. It allows a greater opportunity for study in other fields. This latter program is also suitable as a background for graduate study but with some catch-up work as a graduate student. Either undergraduate degree program can be used as a basis for further work in an interdisciplinary area such as astrophysics, medical physics, biophysics, chemistry, geophysics, electrical engineering, computer science, materials science, mathematics, etc. This work may be done either in the course of a career or it may be part of additional study.

Students may major in Physics in either the Department or in Lyman Briggs School, which is a residential unit in the College of Natural Science. The programs described herein are given assuming the student is in the Department. The programs for the Lyman Briggs students would be very similar to these.

Similarly, students may earn a B.S. degree in Astrophysics. A separate pamphlet describes this program.

Students interested in the B.S. degree with an emphasis on experimental physics as a preparation for positions in Government and Industry should refer to page 11 for advice on how to choose electives with this goal in mind.

Those interested in graduate work are referred to page 12 for suggested choices of electives to best further this goal.

Students who are intending to major in physics are urged to consult the Office of Student Affairs, Room 106 Physics Astronomy Building, for assistance in planning an undergraduate program.

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UNIVERSITY REQUIREMENTS for an UNDERGRADUATE DEGREE

The college and university requirements for a B.S. degree are listed in the MSU Catalog. On this and the following page they are listed as they explicitly apply to a physics major.

Completion of the University's Integrative Studies sequences and the First Year Writing course is required for each student. Courses must be completed in each of the following areas (for lists of approved courses, consult the current "*Schedule of Courses and Academic Handbook*").

- (a) *First Year Writing*. This course may be completed in the first or second semester, but for physics majors the first semester best suits scheduling, enabling the student to begin Physics, for example, in the second semester of the first year, after a semester of introductory calculus.
- (b) *Tier II Writing*. This is to be completed in the major. See page 9 for how this is to be completed for physics majors.
- (c) *Integrative Studies in the Social Science*. Two semesters, 8 credits are required – one course at the 200-level and one course at the 300-level. Either the sophomore year or the junior year would be a suitable year to take these courses. It is also possible to take one semester in each of these two years.
- (d) *Integrative Studies in the Arts and Humanities*. Two semesters, 8 credits are required. The junior and senior years are optimum times to include these courses in the program.
- (e) *Integrative Studies in Biological and Physical Science*. This requirement is fulfilled by the College of Natural Science requirements on the next page.
- (f) All students must complete a *Capstone* course or courses in the senior year which synthesizes the four-year experience. For physics majors there is an option of two possible ways to satisfy this requirement. See page 10 for the options.

Credits to satisfy basic University requirements: **23-24**

COLLEGE OF NATURAL SCIENCE B.S. DEGREE REQUIREMENTS

To satisfy the requirements for a B.S. degree in one of the disciplinary areas in the College of Natural Science a student must:

- (a) Complete *one course* from the following list.
- | | |
|--|-----------|
| BOT 105, Plant Biology | 3 Credits |
| BS 110, Organisms and Populations | 4 Credits |
| BS 111, Cells and Molecules (the lab is a separate course) | 3 Credits |
| ENT 205, Pests, Society and Environment | 3 Credits |
| MPH 205, Allied Health Microbiology | 3 Credits |
| PSL 250, Introductory Physiology | 4 Credits |
| ZOL 141, Introductory Human Genetics. | 3 Credits |
- (b) Complete:
- | | |
|--|-----------|
| CEM 161, General Chemistry I Laboratory | 1 Credit |
| CEM 141, General Chemistry I or CEM 151, Chemistry I | 4 Credits |
| CEM 142, General Chemistry II or CEM 152, Chemistry II | 3 Credits |
- (c) Complete:
- | | |
|--------------------------------|-----------|
| MTH 132, Calculus I | 3 Credits |
| MTH 133, Calculus II | 4 Credits |
- (d) Complete:
- | | |
|---|-----------|
| PHY 183, Physics for Scientists and Engineers I | 4 Credits |
| or | |
| PHY 183B, Physics for Scientists and Engineers I CBI | 4 Credits |
| or | |
| PHY 193H, Honors Physics I – Mechanics | 3 Credits |
| AND Complete: | |
| PHY 184, Physics for Scientists and Engineers II | 4 Credits |
| or | |
| PHY 184B, Physics for Scientists and Engineers CBI II | 4 Credits |
| or | |
| PHY 294H, Honors Physics II – Electromagnetism | 3 Credits |

Total credits to satisfy College requirements: **25-28**

COLLEGE OF NATURAL SCIENCE B.A. DEGREE REQUIREMENTS

To satisfy the requirements for a B.A. degree in one of the disciplinary areas in the College of Natural Science a student must:

- (a) Complete *one course* from the following list.
- | | |
|--|-----------|
| BOT 105, Plant Biology | 3 Credits |
| BS 110, Organisms and Populations | 4 Credits |
| BS 111, Cells and Molecules (a lab is a separate course) | 3 Credits |
| ENT 205, Pests, Society and Environment | 3 Credits |
| MPH 205, Allied Health Microbiology | 3 Credits |
| PSL 250, Introductory Physiology | 4 Credits |
| ZOL 141, Introductory Human Genetics | 3 Credits |
- (b) Complete:
- | | |
|---|-----------|
| CEM 161, General Chemistry I Laboratory | 1 Credit |
| CEM 141, General Chemistry I <i>or</i> CEM 151, Chemistry I | 4 Credits |
- (c) Complete:
- | | |
|--------------------------------|-----------|
| MTH 132, Calculus I | 3 Credits |
| MTH 133, Calculus II | 4 Credits |
- (d) Complete:
- | | |
|--|-----------|
| PHY 183, Physics for Scientists and Engineers I | 4 Credits |
| or | |
| PHY 183B, Physics for Scientists and Engineers I CBI | 4 Credits |
| or | |
| PHY 193H, Honors Physics I – Mechanics | 3 Credits |
- (e) Complete six additional credits of Arts and Humanities or Social Sciences and Economics beyond the basic University requirements.

Total credits to satisfy College requirements: **24-26**

DEGREE REQUIREMENTS BACHELOR OF SCIENCE IN PHYSICS

The B.S. degree in physics provides a thorough foundation in the field of physics together with a strong background in mathematics and a balanced program in liberal arts. It is designed for those students who have an interest in physics as a career and/or those planning for graduate study. It can serve as a foundation for additional study in other disciplines. The requirements for the Bachelor of Science degree are:

1. The University graduation requirements as listed on page 4.
2. The graduation requirements for the Bachelor of Science degree in the College of Natural Science as listed on page 5.
3. In addition to the introductory physics course requirements that are part of the College of Natural Science requirement, the following courses must be completed by a student to fulfill the requirements for the B.S. in Physics.

PHY 191, Physics Laboratory for Scientists I	1 cr.
PHY 192, Physics Laboratory for Scientists II	1 cr.
PHY 215, Thermodynamics & Modern Physics	3 cr.
PHY 321, Classical Mechanics	3 cr.
PHY 410, Thermal & Statistical Physics	3 cr.
PHY 440, Electronics	4 cr.
PHY 451, Advanced Laboratory	3 cr.
PHY 471, Quantum Mechanics I	3 cr.
PHY 481, Electricity & Magnetism I	3 cr.
MTH 234, Multivariate Calculus I	4 cr.
MTH 235, Multivariate Calculus II & Differential Equations	3 cr.
4. Complete two additional mathematics courses at the 300 level or above (6 cr.).
5. Complete the Unit Capstone/Synthesis Experience (3 to 6 cr.). See page 10 for a list of the possible options.

The above list includes those courses which a student must complete to satisfy the *minimum* requirements for a B.S. degree in physics. Any student who plans graduate study in physics after the B.S. should expect to complete more than the above courses in order to better prepare for graduate school. The second semester of two-term sequences in mechanics, electrodynamics, and quantum mechanics, for example, should also be included in the program as well as additional laboratory experience. This will *not* make it necessary for a student to take more than the 120 semester credits needed for an undergraduate degree at Michigan State University. After completing the number of credits needed to satisfy the basic University requirements (23-24), the College of Natural Science requirements (25-28), and the department requirements listed above (42-45), a student still has 23 to 30 elective credits available.

DEGREE REQUIREMENTS BACHELOR OF ARTS IN PHYSICS

The B.A. degree is available for those students who desire a physics major combined with a broader education in liberal arts and in other fields.

The requirements for the Bachelor of Arts degree are:

1. The University graduation requirements as listed on page 4.
2. The graduation requirements for the Bachelor of Arts degree in the College of Natural Science as listed on page 6.
3. In addition to the introductory physics course requirements that are part of the College of Natural Science requirement, the following courses must be completed by a student to fulfill the requirements for the B.A. in Physics.
 - a. Complete:

PHY 191, Physics Laboratory for Scientists I	1 cr.
PHY 192, Physics Laboratory for Scientists II	1 cr.
 - b. Complete one of the following.

PHY 184, Physics for Scientists & Engineers II	4 cr.
PHY 184B, Physics for Scientists & Engineers II CBI	4 cr.
PHY 294H, Honors Physics II–Electricity & Magnetism	3 cr.
 - c. Complete one of the following.

PHY 215, Thermodynamics & Modern Physics	3 cr.
PHY 215B, Thermodynamics & Modern Physics CBI	3 cr.
 - d. Complete:

PHY 321, Classical Mechanics	3 cr.
PHY 410, Thermal & Statistical Physics	3 cr.
MTH 234, Multivariate Calculus I	4 cr.
MTH 235, Multivariate Calculus II & Differential Equations	3 cr.
 - e. Complete one of the following.

PHY 471, Quantum Mechanics I	3 cr.
PHY 481, Electricity & Magnetism I	3 cr.
 - f. Complete one of the following Laboratory Courses.

PHY 431, Optics I	3 cr.
PHY 440, Electronics	4 cr.
4. Complete one additional mathematics course at the 300 level or above.
5. Complete the Unit Capstone/Synthesis Experience. See page 10 for the possible options.

TIER II WRITING REQUIREMENT for PHYSICS MAJORS

To complete the University's Writing requirements for an undergraduate degree, a student must satisfy a Tier II Writing in the Major requirement after having completed the Tier I First Year Writing (ATL) course. For Physics majors the Tier II requirement will be satisfied by completing *all* courses in one of the three *clusters* of courses listed below. All students enrolled in these courses will be required to be involved in the writing activities. However, to complete the Tier II writing requirement in this major, a student must complete all of the courses in one of the three clusters. A student may choose either a laboratory cluster, a research and thesis cluster, or a lecture course cluster. In each of these clusters the nature of the writing style is appropriate to what physicists are expected to present as professionals and the writing is an integral part of the course and the material presented. These groupings are as follows.

LABORATORY CLUSTER

PHY 431, Optics I 3 Credits
 PHY 440, Electronics..... 4 Credits
 PHY 451, Advanced Laboratory 3 Credits

In each course the student's laboratory notebook will be graded for writing style and format. In addition, at least one laboratory report, written as a journal article, will be graded for style, grammar, and form, as well as for content and presentation, and there will be at least one return with feedback of the journal style paper with suggestions for revisions. All three of these is required if this cluster is selected.

THESIS CLUSTER

PHY 390, Physics Journal Seminar 1 Credit
 PHY 490, Senior Thesis 2-4 Credits

In the junior course the students will concentrate on library research, written reports, and oral presentations. The senior thesis will require some laboratory research on the part of the student which normally will take two semesters of enrollment and effort. The completed thesis will be graded not only on the basis of its physics content and accomplishment, but also for style and grammar. It is expected that in both courses there will be several iterations of the submitted material with feedback from the instructor about the content and the writing. Both courses are required to satisfy the Tier II writing requirement if this cluster is selected.

LECTURE COURSE CLUSTER

PHY 491, Atomic, Molecular, & Condensed Matter Physics 3 Credits
 PHY 492, Nuclear & Elementary Particle Physics 3 Credits

Associated with these two senior-level courses the students will receive the capstone culmination of most of twentieth-century physics. In each of these the student will be expected to choose a particular aspect of twentieth-century physics and present a written essay of twenty to thirty pages which will be judged not only on the basis of its scientific content and effort but also on the basis of style, grammar, and structure. There will be feedback and revisions will be expected. Both courses are required if this cluster is selected.

CAPSTONE/SYNTHESIS EXPERIENCE

for

PHYSICS MAJORS

The University's bachelor's degree requirements strongly recommend that all students round out their undergraduate experience with a senior capstone course or courses in the major which draw together in focus the pieces of the four-year program as a synthesizing experience. The Physics and Astronomy Department's implementation of the capstone experience for physics majors emphasizes the development of the science since the beginning of the century and where it might lead in the future for the science as well as for the individual. A student may choose a strictly classroom focus for this capstone or a laboratory/writing experience culminating in a senior thesis. These options are as follows.

THESIS FOCUS

PHY 490, Senior Thesis 2-4 Credits

The senior thesis will require some laboratory research on the part of the student which normally will take two semesters of enrollment and effort. It is expected that the scope of the project will be such that knowledge and experience gained in previous courses will be drawn upon and brought into focus. The completed thesis will be graded not only on the basis of its physics content and accomplishment, but also for style and grammar, satisfying the Tier II writing requirement as well. In the course of the writing it is expected that there will be several iterations of the submitted material with feedback from the instructor about the content and the writing. If PHY 390 is also completed, completing the Capstone experience this way will also satisfy the Tier II Writing in the Major requirement.

COURSE FOCUS

PHY 491, Atomic, Molecular, & Condensed Matter Physics 3 Credits

PHY 492, Nuclear & Elementary Particle Physics 3 Credits

Associated with these two senior-level courses the students will receive the capstone culmination of most of twentieth-century physics in which all of the basic physics learned in the previous courses will be applied to the explication of the major developments of twentieth-century physics at the atomic, nuclear, and subnuclear levels. In each of these the student will be expected to choose a particular aspect of twentieth-century physics and present a written essay of twenty to thirty pages which will be judged not only on the basis of its scientific content and effort but also on the basis of style, grammar, and structure. There will be feedback and revisions will be expected. Thus, the Tier II writing requirement may be satisfied as well.

CHOICES of ELECTIVES BASED on POST-GRADUATE PLANS

POSITIONS in GOVERNMENT and INDUSTRY

Students who plan to enter the industrial employment market after completing a bachelor's degree are advised to consider carefully how they use the elective credits that are available to them after they have satisfied the basic degree requirements as described on pages 7 and 8. To compete in the employment market applicants must be able to point to skills they have acquired that make them attractive to prospective employers. In the majority of cases employers are seeking physicists with laboratory skills, computer experience, and *writing skills* sufficient to the communication needs of a successful research laboratory. While the basic B.S. degree requirements include the Advanced Laboratory course, PHY 451, and a junior level lab course (*Electronics*), a degree with only these laboratory courses completed will not appear very attractive on a resumé. Our recommendation is that students who have these goals take advantage of the availability of the additional advanced laboratory courses that we offer as well as the research involvement leading to a Senior Thesis to enhance their skills. With two optics courses, electronics, two advanced laboratories, and a Senior Thesis (credited as PHY 490) a student can develop sufficient skills to put him/her in a good position when job hunting. Below are listed all of the laboratory courses beyond the introductory ones, including the ones required for the degree and the recommended electives.

Courses	Credits
PHY 431, Optics I	3
PHY 440, Electronics	4
PHY 432, Optics II	3
PHY 451, Advanced Laboratory	3
PHY 452, Advanced Projects	3
PHY 490, Senior Thesis	2-4

PREPARATION for GRADUATE SCHOOL

A student who expects to continue his or her studies after the completion of the bachelor's degree should complete more than the list of required courses which are listed, for example, on page 7 for the B.S. degree. To succeed in most graduate programs, especially a Ph.D. program, a student should complete two semester courses each on quantum mechanics, classical mechanics, and electricity and magnetism. Furthermore, most students will need more laboratory skills to be successful in most graduate programs than is obtained by completing the minimum B.S. requirements. Below are listed some suggestions of electives that a student should consider seriously if he/she is planning graduate study.

Courses	Credits
PHY 422, Mechanics II	3
PHY 472, Quantum Physics II	3
PHY 482, Electricity & Magnetism II	3
PHY 491, Atomic, Molecular, & Condensed Matter Physics	3
PHY 492, Nuclear & Elementary Particle Physics	3
Laboratory Courses Beyond the Minimum Requirement — at least two additional courses from	
PHY 431, Optics I	3
PHY 432, Optics II	3
PHY 452, Advanced Projects Lab	3
PHY 490, Senior Thesis	2-4

FOREIGN LANGUAGE

No foreign language is *required* to complete a degree in the College of Natural Science. However, each student should decide for herself/himself whether her/his future plans may include situations where facility in one or more foreign languages may be advantageous to success in a career. In that case, the place to start gaining proficiency in a foreign language is while in an undergraduate program.

OVERSEAS STUDY

There are many overseas exchange programs in the University which enable students to spend one or two semesters at a university abroad while earning MSU Graduation credits. In the Physics & Astronomy Department we participate in an exchange program (TASSEP) which enables a student to study at an overseas university while satisfying degree requirements here and *paying tuition at MSU*. The ideal year in which to take a year abroad would be the Junior Year. Students participating in such overseas study will be able to do so without having to spend an additional year in the bachelor's program if they arrange the courses when studying overseas such that they complete the equivalent of our first semester quantum mechanics course (PHY 471), the equivalent of our thermal and statistical physics (PHY 410) and a year of mathematics while they complete 15 MSU credits per semester at the overseas site. In recent years students have attended the University of Lancaster in England and were enthusiastic about the experience when they returned for their senior year at MSU. There are possibilities to attend one of more than 10 TASSEP participating schools in England, Scotland, Ireland, Germany, France, Italy, Belgium, Spain and Greece. Information about such exchange programs may be obtained in the Physics & Astronomy Offices or in the Office of Study Abroad in the International Center.

TEACHER CERTIFICATION

Students who plan to teach physics in secondary schools after graduation will need to complete the Teacher Certification requirements of the College of Education as well as the requirements for the bachelor's degree in physics. Interested students are referred to the College of Education for the current status of the certification process.

CHEMICAL PHYSICS

A major in Chemical Physics provides a strong foundation in chemistry, physics and mathematics for those students having a professional interest in the areas of overlap between chemistry and physics. It is particularly suitable for students planning a graduate degree in chemical physics. Interested students are referred to the Department of Chemistry for specific information about this program.

SAMPLE SCHEDULE for the B.S. PROGRAM

<i>FIRST YEAR</i>			
FALL SEMESTER		SPRING SEMESTER	
PHY 170	3	PHY 183 or 193H ^(e)	4 or 3
PHY 101 ^(a)	1	PHY 102 ^(b)	1
ATL ^(c)	4	BIO ^(g)	3 or 4
MTH 132 ^(d)	3	MTH 133 ^(d)	4
CEM 151 or 141 ^(f)	4	CEM 152 or 142 ^(f)	3
		CEM 161	1
TOTAL CREDITS	15	TOTAL CREDITS^(h)	15 or 17

NOTES and COMMENTS:

- a) PHY 101, *Concepts in Physics*, is a 1-credit seminar course whose intent is, among other presentations, to introduce students to Physics as a profession/career. There is a one hour of lecture or discussion seminar per week.
- b) PHY 102, *Physics Computations I*, is a 1-credit computation laboratory course which will be followed by courses *II, III, and IV* in the other three years of a baccalaureate program. In this course computational techniques, software, etc., will be introduced to enable students to develop skills at using computers to solve physics problems. In later physics courses, homework may be assigned that requires computer methods.
- c) ATL is a first year writing course that every student must complete. For majors in physics the first or second semester of the first year are suitable times to satisfy this requirement. Students may complete either Biology or ATL in the Fall, or vice versa.

- d) The calculus sequence MTH 132, MTH 133, MTH 234, and MTH 235 are to be completed by a physics major in the first two years in the program. Students who begin the sequence in the first semester of the freshman year may also start the calculus-level physics sequence at the same time. However, our recommendation is that the beginning student delay the lecture course until the second semester. There will be a first term laboratory course available (PHY 170, *Investigations in Physics*), which requires no prior college physics experience as a prerequisite and which enables the student to gain insights into the relation between observation and analysis. Students with exceptional math skills have honors courses available which may be taken in place of the above listed mathematics courses. A mathematics adviser should be consulted before a student enrolls in such honors courses.
- e) Instead of PHY 183 and PHY 184, Physics Majors who have good math skills, who are in the Honors College, and receive a grade of 3.5 or better in the calculus course in the Fall Semester, may be advised to enroll in the Honors course, PHY 193H, in the Spring. The sequence PHY 193H and PHY 294H is a higher level introductory sequence, covering the various topics in more depth and with a greater reliance on calculus skills than the PHY 183 and PHY 184 sequence.
- f) With standard high school preparation a student normally completes the minimum College of Natural Science requirement in chemistry in the first year. CEM 151 and CEM 152, plus the laboratory course, CEM 161 will satisfy this College requirement. Students may also satisfy the requirement by completing the CEM 141 and CEM 142 sequence instead of CEM 151 and CEM 152. The 141-sequence is for engineering students and other students who do not expect to take additional chemistry courses. Students with a strong interest in chemistry have the option of satisfying the College requirement with the Honors Chemistry sequence, CEM 181H and CEM 182H, plus a laboratory course.
- g) All students in the College of Natural Science must complete one course in Biology to satisfy the University's Integrative Studies requirements in General Science. An alternative track for satisfying this requirement for majors in physics includes a choice among several options of courses which are at a level which is more interesting to science majors and more at their skill level than the standard Integrative Studies courses in Biology that are designed for nonscience majors. For a list of possible courses see item (a) on page 5 of this booklet.
- h) Students who enroll in PHY 183, which is a 4-credit course, may be advised to select a BIO course without a laboratory. Otherwise, the number of credits will be 17 including three laboratory courses.

SAMPLE SCHEDULE for the B.S. PROGRAM

<i>SOPHOMORE YEAR</i>			
FALL SEMESTER		SPRING SEMESTER	
PHY 184 or PHY 294H	4 or 3	PHY 321 ^(b)	3
PHY 191	1	PHY 192	1
PHY 215 ^(a)	3		
PHY 201 ^(c)	1	Elective ^(d)	3 or 4
MTH 234	4	MTH 235	3
ISS 2xx ^(e)	4	ISS 3xx ^(e)	4
TOTAL CREDITS	16 or 17	TOTAL CREDITS	14 or 15

NOTES and COMMENTS:

- a) PHY 215, *Thermodynamics and Modern Physics*, may be taken in the Fall Semester or the Spring. Taking PHY 215 in the Fall enables the student to start the IAH sequence with IAH 201 in the Spring or some other elective, opening up space in the schedule for more advanced electives in the Junior or senior year. If a student wishes to reduce the Fall Semester load PHY 215 can be delayed until the Spring. However, keep in mind that too many semesters of total credits less than 15 may require some summer enrollment.
- b) PHY 321, *Classical Mechanics*, is required, and a prerequisite for higher-level courses. It is offered as a lecture course only in the spring semester. (A CBI version is offered in summer school.) It is very important that physics majors complete PHY 321 in the sophomore year as preparation for higher-level courses.
- c) PHY 201, *Physics Computations II*, is the second course in the sequence of four courses in which students develop computational skills, following the PHY 102 which students should have completed in the First Year. More sophisticated problems are dealt with in PHY 201 and higher level skills will be developed as the demand for these skills arises in other courses.

- d) This is a spot in the schedule where an elective course may be inserted, or a required course, such as IAH 201, may be taken here instead of in the Junior Year as shown in the next sample schedule.

- e) The Sophomore Year is a convenient time in a physics major's program to complete the University's eight-credit Integrative Studies in Social Sciences requirement. For a listing of the courses which satisfy this requirement, one at the 200-level and one at the 300-level, consult the University's catalog of courses.

SAMPLE SCHEDULE for the B.S. PROGRAM

<i>JUNIOR YEAR</i>			
FALL SEMESTER		SPRING SEMESTER	
PHY 471 ^(a)	3	PHY 410 ^(b)	3
MATH ^(c)	3	MATH ^(c)	3
IAH 201 ^(d)	4	(PHY 472) ^(a)	(3)
(PHY 422) ^(e)	(3)	PHY 440 ^(f)	4
PHY 431 ^(g)	3	(PHY 390) ^(h)	1
PHY 301 ⁽ⁱ⁾	1	(PHY 432) ^(g)	(3)
TOT CR	16 or 17	TOT CR	14 or 15

NOTES and COMMENTS:

- a) PHY 471, *Quantum Physics I*, is a B.S. degree requirement. For the B.A. degree either PHY 471 or PHY 481, *Electricity and Magnetism I*, is required. PHY 471 is a prerequisite for PHY 410, *Thermal and Statistical Physics*, which is also a required course (for both B.S. and B.A. candidates). Courses in parentheses are elective courses, not required for the B.S. degree, but a student planning graduate work should seriously consider taking many of the courses recommended above.

- b) PHY 410, *Thermal and Statistical Physics*, is also required for both the B.S. and the B.A. degrees. The Spring Semester of the Junior year is the best time to take this course, especially if one plans to take PHY 491, *Atomic, Molecular, and Condensed Matter Physics*, for which PHY 410 is a prerequisite.

- c) The B.S. in Physics requires two additional mathematics courses at the 300-level or above beyond MTH 235. The B.A. requires one additional mathematics course (see pages 7 and 8). One good choice is a course in linear algebra—either MTH 309 (Linear Algebra I) or MTH 314 (Matrix Algebra with Applications). Other recommended courses for B.S. candidates are Partial Differential Equations (MTH 442), Boundary Value Problems (MTH 443), Complex Analysis (MTH 425), Advanced Calculus (MTH 424), or Applied Linear Algebra (MTH 415). Of course, the student is urged to follow her or his own interests in mathematics in satisfying this requirement.

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- d) Eight credits of *Integrative Studies in the Arts & Humanities* is a University requirement that, for a major in physics, may be satisfied any semester after the first year. The Fall Semester of the junior year, suggested above, is a convenient time to begin this two-semester sequence with the first course of this sequence, IAH 201, which is the prerequisite to all the other IAH courses. See the University catalog for a listing of second courses of the sequence which are available for satisfying this requirement.
 - e) Students planning graduate study are advised to take both semesters of the Mechanics sequence, PHY 321 in the Spring of the sophomore year and PHY 422, *Mechanics II*, in the Fall of the junior year.
 - f) A bachelor's candidate with a major in physics must complete PHY 451, Advanced Senior Laboratory, for which PHY 440, *Electronics*, is the prerequisite. Spring Semester of the Junior year is the appropriate semester to take PHY 440.
 - g) PHY 431, *Optics I*, and PHY 432, *Optics II*, have been referred to in this document (page 11) as valuable courses for someone planning to seek employment in industrial or government laboratories. Modern optics subjects such as holography, non-linear optics, Piezo-electric control, and Fourier optics are some of the advanced topics included in PHY 432.
 - h) The *Physics Journal Seminar*, PHY 390 is intended to be a junior year course. It can be used to satisfy part of the Tier II writing requirement along with the *Senior Thesis*, PHY 490 (see page 9).
 - i) PHY 301, *Physics Computations III*, is the third installment of the sequence of courses intended to develop computational skills that will be needed in other parts of the undergraduate program and beyond.

SAMPLE SCHEDULE for the B.S. PROGRAM

<i>SENIOR YEAR</i>			
FALL SEMESTER		SPRING SEMESTER	
PHY 481 ^(a)	3	(PHY 482) ^(a)	(3)
PHY 451 ^(b)	3	(PHY 452) ^(b)	(3)
(PHY 491) ^(c)	(4)	(PHY 492) ^(c)	(3)
Elective	3	HUM II ^(d)	4
(Thesis) ^(e)	(1)	(Thesis) ^(e)	(1-3)
PHY 401 ^(f)	1		
TOT CR	15	TOT CR	14-15

NOTES and COMMENTS:

- a) PHY 481, *Electricity & Magnetism I*, is a B.S. degree requirement. For the B.A. degree either PHY 471, *Quantum Physics I*, or PHY 481 is required. Courses in parentheses such as PHY 482, *Electricity & Magnetism II*, are elective courses, not required for either degree, but a student planning graduate work should seriously consider taking such courses which are listed in the sample schedules.

- b) PHY 451, *Advanced Laboratory*, is required for the B.S. and optional for the B.A. degrees. It is offered in the Fall Semester and the Senior year is the appropriate time to take this course. The prerequisite for PHY 451, in addition to senior status, is the completion of PHY 440, *Electronics*.

- c) The two courses, PHY 491, *Atomic, Molecular, & Condensed Matter Physics*, and PHY 492, *Nuclear & Elementary Particle Physics*, are senior courses which, while they are elective, play a significant role in satisfying the degree requirements. Taken together they can satisfy both the Tier II writing requirement (see page 9) and the capstone/synthesis requirement (see page 10). Each of these requirements has more than one option including these courses.

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- d) The two courses in *Integrative Studies in the Arts and Humanities* may be completed whenever it fits into an individual schedule in the Junior or Senior years. The above suggested schedule illustrates a program where the two courses are split between these two years. In any case, IAH 201 must be the first course of the sequence.
 - e) A senior thesis is also one of the optional ways for completing the Tier II writing requirement and the Capstone/Synthesis requirement. It is an important experience for students who plan further study as graduate students or who expect to choose industrial or government laboratory employment after graduation.
 - f) PHY 401, *Physics Computations IV*, is the last of the one-per-year computation skills courses.

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