The Major Curriculum in Physics at Gustavus Adolphus College

A. Introduction

The Physics Department at Gustavus Adolphus College offers a comprehensive undergraduate major that is directed toward preparing students for graduate and professional degree work in physics, engineering, and a variety of related fields. The major is built upon courses that are designed to be taken in a specific sequence. These courses, together with others in mathematics, and the lab sciences, will account for approximately half of the academic credit earned by majoring students during their four years. The purpose of this document is to expand upon the information in the college catalog, and to focus on the structure of the program, which is taken by most students preparing for advanced degree work (typically over 85% of our majors).

The physics major curriculum divides neatly along freshman-sophomore and junior-senior lines. During the first two years, students study the principles of classical and modern physics, using differential and integral calculus throughout. The four-course sequence of Classical Physics I, II, III, and Modern Physics constitutes an elementary yet quantitative and thorough introduction to the basic principles of classical mechanics, thermal physics, wave phenomena, optics, classical electro-magnetism, DC and AC circuits, special relativity, quantum mechanics, condensed matter, atomic and nuclear physics. A required laboratory course in electronics and instrumentation in the fourth semester provides an introduction to analog and digital circuits and measurements and the necessary background for the more advanced laboratories to follow. Students will also take three co-requisite mathematics courses (Calculus I, II and Multivariable Calculus), and one half-course in mathematical methods in physics and engineering offered by the Physics Department with faculty from the Mathematics and Computer Science Department. Entering first-year students with demonstrated proficiency in calculus may be able to start with Calculus II or Multivariable Calculus.

During the upper-class years, the student will see virtually all of the basic principles of physics extended in courses at a more advanced level of conceptual and mathematical sophistication. The student's experience with modern laboratory instrumentation and techniques is similarly extended through a required experimental modern physics laboratory, and elective courses in electronics and instrumentation, optics, condensed matter physics, astrophysics, and nuclear physics.

The interdependence of the physics and mathematics courses in the curriculum for majors is no accident. It is a product both of the unity of the natural phenomena and the concepts that underlie our quantitative understanding of these phenomena. The sequential or stepping-stone character of the courses reflects this interdependence, as well as the need to match the level of the courses to the student's mathematical and conceptual sophistication. The prerequisites and co-requisites listed with each major course are the most obvious indicators of the background assumed for a student in a given course.

Because of the relatively small size of the department, and because of our commitment to offer courses for general education and for students majoring in other departments, the major courses are only offered once each year. For example, Classical Physics I is only offered in the fall semester. This fact, coupled with the sequential nature of the curriculum, places a heavy emphasis on good planning and accurate advising. This is especially critical for entering students who may be considering a physics major with advanced degree or pre-professional goals.

It is possible to fulfill the minimum graduation requirements for a major in physics during the last three years in residence if the mathematics courses (Calculus I and II) are taken in the freshman year. However, even with a doubling up of courses and some adjustments of prerequisites, it will not be possible for a student to take the full sequence of courses that is recommended for graduate school in physics or electrical engineering. Scheduling problems are much more likely to occur when upper-class students are behind in the major sequence. In addition, the required experimental modern physics laboratory and junior-senior theory courses presume a background gained in preceding courses. Waivers of specific course requirements for the major will be considered by petition to the chair of the department.

It is the strong recommendation of this department that any student considering a major in physics enroll in PHY-200/201 Classical Physics I & lab, and either MCS-121 Calculus I, or MCS-122 Calculus II in the fall of the first year. A detailed plan of study that assumes the normal sequence is shown on page 3.

B. Review of Degree Requirments and Plan of Study

The requirements for the B.A. degree with the major in physics are published in the College Catalog and are summarized below. In the rest of this section we show how most of our majors pursue their studies through eight semesters, while keeping open a range of options for graduate and professional studies. Students wishing to pursue a pre-engineering emphasis or dual-degree program in engineering will follow essentially the same plan through at least the or junior year. The normal course load is 4.25 - 4.50 course credits per semester. (A maximum of 4.75 credits may be taken without payment of an overload fee, except for students who qualify under the Overload Guidelines in the College Catalog. This department will support overload fee waiver petitions from students with GPA 3.5 or better when students are earning credit for Honors in Physics, or for faculty-student or independent study research in physics.)

Summary of Requirements for the Physics Major:

1. specific courses in physics and pre/co-requisite courses in mathematics;
2. a minimum of 9.75 course credits in physics, with none graded below C-;
3. one laboratory science course outside the department;
4. one course with a project component from either PHY-310, PHY-320, PHY-340, or PHY-360.

The general education courses for students who follow either Curriculum I or II will be taken in parallel with major and elective courses, and should be largely completed by the end of the junior year. Students completing MCS-121 or MCS-122 (Calculus I or II) will automatically satisfy the Curriculum I requirement in Quantitative Reasoning (QUANT or MATHL). Since none of the physics courses that are designed for the major also satisfy the laboratory science (LAB or NASP) requirements, majors must take such a course from another department. This means that the laboratory science requirement outside the department for the physics major will typically be satisfied by the required general-education laboratory science course. General Chemistry (CHE-107) is the course recommended for physics majors, unless they enter with AP credit in chemistry, but other courses are also possible. The writing requirement in Curriculum I will be partially satisfied by completing a First-Term Seminar and PHY-305 Experimental Modern Physics Lab.

The on-line registration system requires concurrent registration in labs for courses with required laboratory components. In the introductory and intermediate courses, the lab receives separate credit and grade; while in the advanced courses, the course and lab credit and grade are integrated, even though the laboratory has its own course number and meeting times.

The program outlined below assumes the Curriculum I option, and does not show the required Lifelong Fitness and Activity courses, nor does it show any fractional credits for musical or other activities.

First Semester of First Year	*Second Semester of First Year*
PHY-200 Classical Physics I	PHY-220 Classical Physics II
PHY-201 Classical I Lab (0.25)	PHY-221 Classical II Lab (0.25)
MCS-121 Calculus I	MCS-122 Calculus II
FTS-100 First-Term Seminar	General Education
General Education (Possibly CHE-107)	General Education/Elective

First Semester Sophomore	*Second Semester Sophomore*
PHY-240 Classical Physics III	PHY-260 Modern Physics
PHY-241 Classical III Lab (0.25)	PHY-270 Electronics I
MCS-222 Multivariable Calculus	PHY-271 Electronics I Lab (0.25)
General Education/Lab Science	PHY-230 Math Methods (0.5)
General Education	General Education
	General Education/Elective

January Term of First and Sophomore Years
PHY-210 Introduction to Fortran and C++, MCS-273 Introduction to C++, CHE-202 Materials Science, or other course

First Semester Junior	*Second Semester Junior*
PHY-300 Mechanics	PHY-350 Electromagnetic Theory
PHY-305 Experimental Mod. Physics	PHY-370 Advanced Math Methods of Phys.
General Education/Elective	General Ed./Elective/PHY-320, 330, 340 or 360
General Education/Elective	Elective

First Semester Senior	*Second Semester Senior*
PHY-380 Thermal and Stat. Phys (0.75)	PHY-360 Optics with lab
PHY-390 Intro to Quantum Mechanics	PHY-320 Astrophysics*, PHY-330*, or PHY-340*
PHY-399 Physics Seminar (0.25)	General Education/Elective
General Education/Elective	Elective

January Term of Junior or Senior Year
PHY-310 Electronics II*, PHY-330 Nuclear Physics*, PHY-340 Condensed Matter Physics*, MCS-273 Introduction to C++, PHY-391 Research, or other course or experience.

* These courses are offered on a rotating 2-3 year schedule, alternating between spring semester and January Terms. Each fall semester, a preliminary schedule of 300-series courses for January and spring is circulated, and student plans and preferences are surveyed.

The Department recommends that all students acquire a working knowledge of a high-level language such as C++, Java, or Fortran before graduation. C++ and Java are the most commonly required courses for students in engineering programs. Fortran remains a widely used, high-level language in Physics, and programming background in Fortran is valuable in a variety of summer research and graduate programs. The Department offers PHY-210 Introduction to Fortran and C++ on a January schedule that complements MCS-273 Introduction to C++. The Mathematics and Computer Science Department also offers a number of other courses that may be of interest to physics majors. These include:

MCS-321 Elementary Theory of Complex Variables (spring semester)
MCS-355 Scientific Computing and Numerical Analysis (spring semester, even years)
MCS-357 Discrete Dynamical Systems (fall semester, even years)

Students are encouraged to consult with their advisor and the course instructor to determine which courses from this list, or others in the catalog, might best fit their interests and degree plans. The plan of study outlined above cannot take the place of regular and meaningful faculty-student advising.

C. Honors In Physics

The Physics Department established an honors program in physics with the intention of promoting individual excellence in physics through directed research and demonstration of significant knowledge of the discipline. The requirements are:

1. Completion of a physics major, including PHY-300, PHY-350, PHY-380 and PHY-390
2. A minimum GPA in physics courses of 3.25
3. Completion of at least 1.0 course in research in physics (PHY-291 or PHY-391)
4. Completion of the Graduate Record Exam in Physics
5. Completion and successful defense of a senior thesis based on student's research

Applications for honors in physics must be received by the department chair and accepted before the beginning of the student's last semester. Application forms are available from the department chair.

The senior thesis must be based on the student's research and prepared in consultation with a Gustavus physics faculty member. Copies of the thesis must be submitted to each member of the department at least two weeks before the end of the spring semester. The faculty will read and return the thesis with comments. A formal defense takes place no later than the last week of the semester.

D. Academic Advising in Physics and Pre-Engineering

All of the faculty in physics place a high priority on student advising and enjoy the opportunity to get to know each advisee. However, academic advising is a two-way street. The system will work only if the student keeps his or her advisor informed of that student's progress, evolving interests and immediate or potential problems. The following sections describe the goals of the departmental advising program and outline the expectations for both members of the advising partnership.

First-Year Student Registration and Advising

First-year students normally register for classes in late June with the help of a faculty member from one of the departments in which the student has expressed some interest. Thus, the first semester

schedule is already in place at the time of freshman orientation. However, the College assigns faculty advisors to first-year students based on one of two criteria: (1) enrollment in First-Term Seminar (Curriculum I); or (2) enrollment in Curriculum II. Although the first-year advisor will review the fall course schedule with the student during orientation, this is not a time for major changes in the course schedule worked out during the summer registration. This is particularly important for students who enter with a fairly clear idea of majoring in a science. New students should be wary of advice about curriculum matters from Collegiate Fellows and others who are not majoring in the student's prospective field of study. Well-prepared students are sometimes counseled by well-meaning individuals to take a light load (fewer than four courses) their first semester, or to avoid a certain combination of science and math classes. Unless specifically advised by an academic advisor to take a lighter load for good reason, the beginning student should enroll for 4 - 4.5 course credits.

All first-year students who indicate an interest in physics and who are enrolled in Classical Physics I and II receive information about the physics program in class, and will be invited to establish an early informal advising relationship with one of the instructors of these courses or with another member of the department. The prospective majors should meet with this informal advisor before registration periods to review the plan of courses as part of the exploration of the major or pre-professional program. These informal advisors will monitor student progress in physics and math courses and will offer encouragement and suggestions for avoiding pitfalls.

Students who have indicated an interest in a pre-professional program (such as engineering or medicine) or in a second major are encouraged to meet at an early date with the designated advisor for that program or with a member of the second department. (Please read the caution about double majors at the end of this document.) This will provide the student the opportunity to make sure that he or she is taking the necessary introductory courses in the fields that support a later choice of major or pre-professional program.

Choosing the Major Advisor

During the second semester of the freshman year the student will be encouraged to obtain a faculty advisor from the student's major department. Most first-year students who are considering a physics major will be enrolled in PHY-220/221 Classical Physics II. They will have had classroom experience with two or three faculty from the department, and ideally one of these as an informal advisor. Students with pre-engineering plans should have been meeting with Prof. Saulnier, the pre-engineering advisor. It would be natural for the student to approach one of these teachers about his becoming the student's faculty advisor. In order to equalize the advising loads and to accommodate student interest in particular specialties or professional programs, the department may encourage the student to sign up with one of the other faculty members from whom the student will be taking courses in the sophomore year. In any case, a member of the physics faculty would then become the student's advisor of record by signing the appropriate form.

We encourage students to become familiar with the major curriculum and opportunities for other activities carried out by the department as soon as possible. As emphasized previously, the sequential nature of the core courses and the limited number of sections and offerings make it absolutely essential that the student obtain accurate advice about course selection.

Class announcements, e-mail messages, meetings with your physics advisor, Society of Physics Students meetings, and departmental bulletin boards are the principal avenues for information of importance to majors and prospective majors. Examples of this sort of information include visiting and student speakers, summer research and internship opportunities, student employment in the department, new courses to be offered, and other curricular matters.

The Advising Calendar

By becoming an advisee, the student agrees to meet with the faculty advisor for academic and career planning, not only for a signature at registration times. For returning students, the first meeting of the year should occur sometime before the end of the second week of the fall semester. The purpose of this meeting is to review the student's course program and discuss the overall plan for the year. The faculty advisor will sometimes post a sign-up sheet for appointments. Of course, if the student finds it necessary to drop or add courses that bear on the major or pre-professional programs, then he or she should discuss these issues with the departmental advisor as soon as the problem arises. It is an essential part of the compact between student and departmental advisor that all substantive changes to the student's course schedule be discussed with the academic advisor in advance of such changes.

The regular meeting in each semester occurs as the student prepares to register for the following semester's courses. January Term and spring semester registration both take place in November. Normally, the student will have worked up a preliminary schedule that the faculty advisor can review. The advisor will check progress toward graduation requirements, as well as discuss the student's plans beyond Gustavus. When the proposed schedule is complete the advisor will electronically approve the registration.

There is a natural evolution in the advising relationship as the student moves into the upper class years. Informal advising goes on all the time, and the small size of most physics courses and the frequent development of mentoring relationships through research and independent studies make this almost inevitable. It is one of the benefits of going to a place such as Gustavus.

E. Double Majors

In general, we do not encourage students to complete the formal graduation requirements for double majors. This usually results in two "minimal majors", and requires the skipping of courses recommended for admission to graduate school in the chosen field. Schedule conflicts between required courses in the two departments are virtually guaranteed. Graduate admissions committees in physics and engineering departments expect all applicants to have strong supporting course work in mathematics, and some background in chemistry and computer science, but they are not usually impressed by a second major on the transcript. Of course, students planning inter-disciplinary graduate work in such fields as geophysics and biophysics will need to take particular heed of the recommended preparation from the graduate departments they expect to apply to. Usually a minor or equivalent course work in the second department is more than sufficient for interdisciplinary specialities.

Those students who pursue or declare two majors are not relieved of the responsibility of establishing an advising relationship with a faculty member from each department. The physics department requires that all students declaring a major in physics establish an advising relationship with a physics faculty member. The signatures of both the physics advisor and the department chair are required on graduation applications.