Academic Program Review
Physics

The Major

a. Overview and History of the Major

Physics is primarily concerned with the basic physical laws that govern the operation of the universe. The beginning of its modern development can be traced to the sixteenth and seventeenth centuries, to people like Galileo and Newton who found that elementary laws or rules could explain and predict the behavior of the physical world around them, e.g. the motion of the planets in the solar system. The fields of thermodynamics and electricity and magnetism developed in the nineteenth century. In the twentieth century the development of relativity and quantum mechanics have had a profound impact our understanding of the world we live in. The development of these ideas has led to many of the technological features we associate with our modern society.

The Physics program was established in the 1960's. It offers a grounding in the fundamental theories and concepts of the discipline, with the goal of preparing graduates for careers in industry or teaching, or to be prepared to enter one of the many graduate programs in physics or related fields at universities nationwide. However, many of the recent developments in physics have not had a major impact on undergraduate curricula in physics. While they are referred to qualitatively in undergraduate courses, the details of many of these phenomena are quite complicated and are usually covered in graduate level courses. Consequently the physics program has not changed appreciably since the last program review in the year 2000.

b. Description of the Major

The Department of Physics, Physical Science, and Geology offers both a B.Sc. and a B.A. degree in physics. Both degree programs have the same foundation, and prepare graduates for industrial or teaching careers. The B.Sc. degree also includes three mathematically challenging courses in Quantum Mechanics and Statistical Physics, and is the preparation needed by students wanting to go on to graduate school. The B.A. degree does not require these classes, and so allows the students to broaden their education with classes in other fields.

The lower division foundation courses for both degree programs are designed to give the students an overview of classical physics[1] and the necessary tools, concepts, and

1 Roughly defined as the concepts and principles of physics prior to the year 1900. It includes the major developments of the fields of mechanics, acoustics, fluid mechanics, electricity, magnetism, and optics.

techniques from the related fields of mathematics and chemistry;

- Phys 2250/2260 General Physics I/II
- Math 1410/1420 Calculus I/II and Math 2410 Multivariate Calculus. Math 2460 Introduction to Differential Equations is also recommended, but not required.
- Chem 1100/1110 Principles of Chemistry I/II

At the upper division level both programs further develop the ideas of classical physics, but at greater depth, including a greater mathematical sophistication, and introduce the ideas and concepts conventionally referred to as modern physics[2]. The B.Sc. degree program includes classes which develop these modern physics ideas to greater depth.

c. Units Beyond 120 for Undergraduate Programs

Students entering the university as freshmen with a solid high school mathematical education can graduate within the 120 unit target.

The required units for the B. Sc. degree are as follows

Prerequisites to the major		32
Major courses		35
General Education Requirement	51	
less areas B1, B3, and laboratory	7	
plus WP (not currently satisfied by major)	3	
	47	47
Total		114

Out of the six units not required for the major, faculty advisors recommend that students take Math 2460 Introduction to Differential Equations. It is also common for entering students to take Math 1100 Precalculus if their high school mathematics preparation does not qualify them to take Math 1410 Calculus I in the Fall semester of their freshman year.

For students pursuing the B. A. degree only 25 units are required in the major, although the number of prerequisites increases to 35 with the addition of CS 1500 Computer Programming I. For these students the total number of required units is thus 107. For the remaining 13 units, students are advised to take other classes in the physical science to broaden their education.

2 Physics after 1900, including relativity, quantum mechanics, statistical physics, atomic, nuclear, and particle physics.

d. Recruitment

The Physics Program tries to make use of all contacts with local schools to promote physics as a degree option. Specifically

- Program faculty are on campus every year for Preview Day.
- Program faculty participate in "Dinner with a Scientist" each spring. Susan Mokhtari and Chris De Vries have both given the dinner presentation to help attract students.
- The Department is involved in public outreach programs which advertise our program, including
  - Public Observation Nights centered around the observatory. These events are usually very well attended, with as many as 300 persons attending.
  - Talks to youth groups such as the Boy Scouts and Girl Scouts
- Program faculty participate in the Career Day organized by the Modesto School District each year.

e. Retention

There are two sides to the issue of student retention within the program. On the negative side, the program has attracted some students who are unable to master the appropriate mathematical skills. We find that these students realize that they are not capable of handling the mathematics that is required of them at the time that they take either Math 1420 Calculus II or Math 2410 Multivariate Calculus, and transfer out of the program. On the plus side, those students who do succeed at this level, and who go on to take physics classes in the major have all graduated or are still working towards graduation.

The Program faculty are aware of the difficulty that some students who declare physics as their major do have with the mathematics, and have discussed at length options for addressing the problem. We are, however, mindful of two important considerations

- The answer to the lack of student preparation is not to "dumb down" the program. Unfortunately the number of students in the program is well short of that which would be required to allow us to offer two tracks, with different mathematical requirements. Whereas we always strive to help all students as much as possible, we feel it vital that we maintain standards.
- To weaken the program would work to the detriment of those students who are capable of handling the material, especially those wanting to go to graduate school. It is a fact of life that Graduate Programs are going to expect a minimum preparation of their entering students, and we must be committed to providing it.

f. Innovations and use of technology

As a technologically oriented discipline we make use of technology whenever appropriate. Some of the computer technology in particular has been incorporated into our curriculum since before the previous Academic Program Review, and we continue to enhance our use of technology wherever its use is appropriate. However, we also recognize that technology can be an aid to instruction, and to the development of student skills, but should not be a substitute for direct classroom interaction.

Some of the ways in which we use technology include:

- interfacing of computers and equipment in laboratory classes.
- where possible for dissemination of course material. (The complex mathematics that is required of some classes precludes distribution over the Internet.)
- Students in laboratory classes (except Phys 1502) are required to use spreadsheet programs and/or other software programs for analyzing experimental data.
- the use of mathematical packages (Maple, Matlab, etc) has recently been incorporated into the physics major. Students are introduced to these packages in Phys 3010 (Mathematical Physics I), which is taken in the Fall semester of the junior year. It s strongly recommended that students purchase the Student Edition for themselves, and to use it in subsequent classes for solving tedious mathematical equations, and for displaying the results of their calculations.

g. Plans for the curriculum

The curriculum of the physics program parallels those at other institutions. It provides a grounding in the fundamental principles, and suits the needs of our students; both those going on to graduate school, and those pursuing a teaching credential. Major changes, especially those that weaken the basics of the program, would put our students at a disadvantage when applying to graduate school.

Despite the constancy of the curriculum, there are opportunities to address pedagogical issues which arise. Foremost amongst these is the mathematical preparation of our students.

- The primary pre-requisite for any student starting the physics program is calculus. The first physics class in the curriculum for the major (Phys 2250 General Physics I) makes use of calculus from the outset. Even students who are well prepared for entry to CSUS need the first year to complete the Precalculus/Calculus I sequence before they can enroll in Phys 2250. As a result, the physics major itself becomes effectively a three year program, which causes significant scheduling problems.

Unfortunately many of our entering freshmen have weaker mathematical skills than is optimal, and need to take other preparatory mathematical classes before commencing the major.

- There is a quantum jump in the mathematical level required of our students between their sophomore and junior years. This is partially addressed by the required core class Phys 3010 Mathematical Physics I, but most majors still struggle with the mathematics in junior and senior level classes.
- The physics program does not have a Writing Proficiency class in the catalog. At the moment students have to take a class out of the discipline. A WP class within the discipline would allow us to offer three more units with physics content, at no net cost to the student.

Student Demographics

a. Statistics

Year	Number of Physics Majors	Number of Physics Graduates
1999-2000	22	2
2000-2001	16	3
2001-2002	21	4
2002-2003	19	2
2003-2004	23	1
2004-2005	30	2
2005-2006	23	2
2006 (Fall)	24	1

The data in his table is comparable with nationwide trends for universities and four year colleges without graduate programs. Of these institutions, approximately two thirds report graduating between 0 and 4 majors per year[3].

b. Diversity

The physics program is relatively small for this campus, which is typical of physics programs at other CSU campuses, and of physics programs nationwide[4]. At the time of preparation of this report 24 students list Physics as their major. Of these five (21 %) are female, which is identical to the number of bachelor degrees in physics awarded to

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3 http://www.aip.org/statistics/trends/highlite/ed/figure9.htm

4 American Institute of Physics (http://www.aip.org/)

female students nationwide[5]. Of the 24, nine are minority students (five Hispanic, two Indian, and one each Middle Eastern and African American). By comparison, nationwide only 13 % of degrees in physics are earned by minority students[6].

Resources

a. Service, Liberal Studies, and General Education Courses

By far the largest fraction of the teaching load for the physics program lies in the classes that we teach outside of the major. All these classes are heavily enrolled. Included in this category are

- Service classes for students in other scientific disciplines. (Phys 2100/2110 Basic Physics and Phys 2250/2260 General Physics)
- LIBS classes. (Phys 1500 Energy and Matter, Phys 3080 How Things Work, and Phys 3200 Heat Light and Sound)
- GE classes. (Astr 2100/3000 Descriptive/Contemporary Astronomy, Phys 1500 Energy and Matter, Phys 3080 How Things Work, Phys 3550 Physics for War, Physics for Peace) The service classes for science majors also qualify for GE credit.

In the current academic year the classes other than those for the physics major account for 90 WTU out of a total of 117 (77%). Counted by SCH the fraction is higher still. The fraction will increase even further in coming years as we offer 'off-sequence' classes in Basic Physics to satisfy the demand from an increasing number of student majoring in Biological Sciences. These non-major courses provide the basis for the resource needs of the department.

b. FTES/SFR

For the 2005/6 AY (the last complete year as of the time of preparation)

- Total SCH = 2808
- Total FTES = 2808/30 = 93.6
- Total FTEF = 4.87 (includes non tenure track faculty)
- SFR = 19.2

The number of students in our classes has risen approximately 8% since the last program review. The Student Faculty Ratio is largely unchanged. It should be noted that this figure would be larger but for three factors:

- All laboratory sections are limited to only twenty students by equipment

5 http://www.aip.org/statistics/trends/highlite/ed/figure10.htm
6 http://www.aip.org/statistics/trends/highlite/ed/table11.htm

constraints.
- All laboratory sections count for one SCH but 2 WTU for the faculty.
- The enrollment in Phys 3200/3 (Heat, Light, and Sound), an Integrative Inquiry class for the Liberal Studies major has a class limit of 24, set by the inclusion of an activity component to this course.

c. Faculty

The physics program currently has four faculty members

- Dr. Marvin Johnson, Ph. D., University of Illinois
  Biophysics (experimental)
- Dr. Ian Littlewood, D. Phil., University of Oxford
  Atomic Physics and Optics (experimental)
- Dr. Lu Rose Zhang, Ph. D., University of California Davis
  Material Science, High T_c Superconductors, Optical Materials (experimental)
- Dr. Susan Mokhtari, Ph. D., Imperial College, University of London
  Nuclear Physics, General Relativity and Gravitation (theory)

With four faculty members, this department is smaller than the average of departments which only offer bachelor's degrees (5.4 faculty members per department) and substantially smaller than all physics departments (11 faculty members per department)[7]. Two of our faculty members are female, and two non-Caucasian, both percentages being well above the comparable figures for the average number of female and minority faculty members nationwide[8,9].

Coverage of expertise areas is not a critical issue in the department. The major portion of a typical undergraduate program such as ours consists of core course work which all faculty members are qualified to teach. Specialized areas of physics are only taught in elective classes, and the degree program requires only one such class. In recent years we have alternated between Phys 4900 (Modern Optics and Lasers) and Phys 4450 (Nuclear and Particle Physics). This gives our students as much of a choice of elective as possible, although most do take both. Two of our upper division classes are either a laboratory class, or have a laboratory component. For these classes an experimentalist is the preferred instructor, and three of the faculty satisfy this criterion.

During the current (2006/7) academic year we are searching for a fifth faculty member, partly justified by the WTU teaching load, and partly justified by the retirement of Dr Tai Low Chow at the end of the Fall 2006 semester.

(Added Spring 2008) The search for a fifth faculty member was brought to a successful

7 http://www.aip.org/statistics/trends/highlite/acad/table1.htm
8 http://www.aip.org/statistics/trends/highlite/women05/table6.htm
9 http://www.aip.org/statistics/trends/highlite/acad/table6.htm

conclusion with the appointment of Dr. Chris De Vries, Ph. D., U. Mass. Amherst, Astronomy (experimental).

d. Advising

All students are allocated a faculty advisor, and are mandated to receive advising before registering for the next semester.

e. Release Time

The head of the program, currently also the chair of the department receives six units of release time. In accordance with college practice new faculty (Dr. Susan Mokhtari and Dr. Chris De Vries) have/do receive 3 units of release time as part of their hiring agreement.

The Physics program has only four (recently increased to five) faculty members, so we cannot afford to award extra credit or rotational sabbatical leave (paid by department) to the faculty members in supporting their research, scholarship and creative activities. Due to the difficulty in replacing faculty of the current expertise, two senior faculty members in the program have not taken sabbatical leave for more than 14 years. However, the program has tried to arrange class schedule to make some Tuesday or Thursday as non-teaching days for some faculty to concentrate on their research, travel, or related activities. In addition, the program has encouraged the faculty to engage in the student research through individual study, and to offset the low FTES generated by having some faculty teach GE classes with large enrollments. In the period covered by this review the program has also supported a faculty member to do research in the industry for 3 years by hiring a visiting lecturer to teach her portion of the teaching load.

f. Mentoring

Mentoring of new faculty is informal, with all tenured faculty willing to help and advise as necessary.

g. Part time faculty

The department employs relatively few part time faculty. Of these, Dr. Danny Birmingham (University of the Pacific) is the only one to have taught a class required by the major, that is Phys 4530 Thermal and Statistical Physics, which he has taught once.

All other part time teaching has been in laboratory classes which support our GE and service classes. The level of part time instruction has been kept relatively stable, rising slightly in recent years due to the commitment to teach the Basic Physics sequence twice a year to accommodate the increased number of majors in Biological Science. It is not expected that significant increases in part time instruction will be needed in the near future

- because the program has a commitment to teaching as much of its classes as possible by tenure track faculty. We have been able to honor this commitment despite an increase in offerings (principally in Basic Physics) by an increase in the number of tenure track faculty from four to five.
- Qualified part time instructors are difficult to find in the local area.

h. Faculty Scholarship

Cutting edge research in physics is expensive, time consuming, and resource dependent. Faculty at this institution cannot compete at this level, they lack equipment money, release time, library resources, and support infrastructure such as fabrication workshops. (It is not uncommon for new faculty at research institutions to be offered start up funds of $½M.) To maintain any research or scholarly activity under these circumstances is in itself a notable achievement.

Nevertheless the faculty has been, and continues to be, active in five areas

- Low temperature superconductivity (Zhang)
- Non linear optical materials (Zhang, during a leave of absence with JDS Uniphase)
- Theoretical gravitation (Mokhtari)
- Astronomy (De Vries, experimental)
- Authoring of textbooks (Chow, recently retired) and instructional software (Littlewood)

i. Grants

- Dr. Rose Zhang:
    - 2005 – 2006, RSCA Grant, Material Investigation and Application of Superconductors.
    - 2007, two female students were awarded a grant to cover some travel expenses in the Conference for Undergraduate Woman in Physics (Los Angeles, January 13, 2007).
    - 2007 – 2008, RSCA Grant, Significant Improvement of Physical Properties In the Superconductors with chemical Substitution.
- Dr. Susan Mokhtari:
    - 2006 – 2007, Faculty Center of Excellence in Learning and Teaching Grant.
    - 2005 – 2006, National Science Foundations Grant (not funded).
    - 2007 – 2008, RSCA Grant, Stability of charged topological black holes in anti-de sitter spacetime.
    - 2007 – 2008, Naraghi Faculty Research Enhancement Grant, Stability of

topological black holes.

- Dr. Chris De Vries:
  - 2007 – 2008, Naraghi Faculty Research Enhancement Grant, A Next Generation Radiative Transfer Project.
  - 2007, $1,250 from the American Astronomical Society to present Star Formation in Bright-Rimmed Clouds: A Comparison of Wind-Driven Triggering with Millimeter and Submillimeter Observations to the 237th Symposium of the International Astronomical Union.
  - 2007, 11,700 Czech Krowns from the International Astronomical Union to present that same paper at the 237th Symposium of the International Astronomical Union.

j. Student Research Work with Faculty Members

Faculty members in our program have continuously offered the research classes through individual studies for student research. During these special sessions, students are engaged in various research projects. As an example, the sequence of superconductivity research class (Physics 4980 – Zhang) is given below:

1. Research Experience in Physics (the first unit of the class)
2. Research Method in Physics (second unit)
3. Undergraduate Research Project in Physics (third unit)
4. Advanced Research in Physics (fourth unit)
5. Introduction to Superconductivity Research (fifth unit)
6. High Temperature Superconductivity Research (sixth unit)

The students (usually sophomore and junior) who sign on the class for the first time will take the first unit of class, Research Experience in Physics, and are expected to attend weekly meeting, group discussion and observation of other senior members in the group for the research planning, experimentation, and sample preparation. The students who take the second-unit class will learn the research methods by first visiting to the library, or browsing the electronic journals. The students are required to engage in extensive self-study on recently published research articles and fundamental theories of superconductivity. Weekly discussion is held for questions and discussion of interesting article. One report is expected at the end of semester from each student. Third-unit students will be grouped to choose a small size research project such as preparation of some samples, or analysis of some experimental data. Through the experience of basic research process including literature search, project planning, background study, and experiment conducting, the students have gained physics knowledge as well as research skills. The students are expected to attend weekly meeting to report research progress, to discuss the problems, and to revise the plan if necessary. At the end of semester, a presentation is expected to report the results of the project. Usually other students in the science disciplines and faculty in the Department are invited. For the students taking 4th or higher unit are seniors, and usually paid by the RSCA grant for the specific projects, and are working closely with the faculty. In addition to attending research activities with other students who are enrolled in lower units, they are expected to plan a weekly meeting, lead group discussion, and work in the projects in the level to disseminate the results at national conferences or through publication.

k. Student Learning

1. As one of the learning goals for student majoring in the program, students "will demonstrate the ability to work effectively in a laboratory environment, including the use of advanced technologies." Due to the lack of laboratory experience for most of our students, a 2-units Advanced Lab (PHYS 4102) has been divided into 2 semesters (one unit each). As such, students have more hours working in laboratory and contacts with the faculty. This directly benefits students in developing their ability to work effectively and independently in the laboratory environment.

2. Every semester the Physics Program offers a research class (through Individual Studies, Phys 4980) to students who want to learn research methods and gain research experience as a team. The students have learned to search and find information in physics literature, and to critically evaluate scientific communications (written or oral). This special course is directly linked to the learning goals of the program in which students "will have a strong command of the nature of oral and written communication and of intra-group interactions in the traditions of physics."

3. We have offered on rotation the upper-division elective classes Modern Optics & Lasers Optics (PHYS 4900) and Nuclear and Particle Physics (PHYS 4450) to students who are interested in pursuing graduate studies or careers in industry[10]. These courses are "to prepare our undergraduate students for graduate school, a career in scientific research and development, or industrial work" as stated in the program's Mission Statement.

4. The department now has approval to offer a new WP class, Spectroscopy Laboratory (PHYS 4910 and 4912), starting in Spring 2009. The course is designed based on the learning goals of the program, and students' current background and future career goals, and will increase the students' laboratory experience. This course serves as a remedy to our students who have had no choice but to take a WP course outside the major, and therefore also improves the program's effectiveness and completeness by offering 3 more units with physics content, at no net cost to the student.

   By taking the class, students will be able to

10 Only one elective is required for the major, although most students choose to take all electives that are offered.

1. master experimental techniques used in spectroscopy to design experiments.
2. analyze the results and form appropriate conclusions.
3. evaluate the uncertainty in numerical results from the propagation of errors from the data.
4. disseminate the experimental results in a fashion acceptable by professionals in scientific community.

l. Equipment

Equipment needs for our teaching laboratories have always been a critical issue for the Physics program, as they have been for all of the departments in the Natural Sciences. A large portion of the equipment in our laboratories is outdated, unreliable, or just plain old. This is particularly true for the upper division laboratories for physics majors, for which individual pieces of equipment are expensive.

The construction of the new Science II building, and the passing of the bond issue which in part funds new equipment for this facility, will help alleviate these problems. However, it cannot be stressed enough that the funds from this bond are not the solution to the problem, for at least two reasons

- Cost overruns in the construction costs for the building required that some of the expenses for building equipment be moved from the building fund to the equipment fund, reducing the amount available for scientific equipment.
- Even if the equipment fund were to fully address current problems with scientific equipment, future issues caused by equipment degrading and technological advances in equipment will require adequate future funds.

m. Classroom space

With so many large classes in all the science departments, a number which continues to increase as we are urged to take more and more students into our classes, scheduling is as always a major problem. With only one classroom in the Science Building holding more than 35 students, and large classes in Biology, Chemistry, Physics, and Geology all competing for this one room it is inevitable that conflicts will occur. Solutions have involved moving classes to other buildings and scheduling at other times, including evenings. The first of these is particularly problematic, since it can involve transporting equipment (some of it delicate) across campus. In many cases it has been decided to not use demonstration equipment in lecture classes, which diminishes the learning experience for the students.

The opening of the new Science Building II will only partially address the problem. Although the classrooms are slightly larger, there are actually fewer classrooms in the new building than there are in the current one. Given the need to use demonstration equipment, it is imperative that the science disciplines take precedence when scheduling classes in these rooms, and in the existing Science Building. We recommend that scheduling of these rooms become the responsibility of the College of Natural Sciences.

n. Physics courses and the GE program

The physics program (including astronomy) has eight lecture classes and three laboratory classes for which students can earn credit in the General Education Program (areas B1 and F1). One of these lecture classes is a component of the Summit cluster program.

Of these classes three qualify for upper division credit in area F1, and are evaluated for their compliance with the goals of the General Education Program.

i. Phys 3080 How Things Work

This class heavily stresses goals 1 (Subject Matter) and 3 (Inquiry and Critical Thinking) of the GE program. The teaching method which has been adopted follows the Peer Instruction method for teaching physics at the introductory level, first developed by Dr. Eric Mazur of Harvard University[11], and which tries to stress understanding rather than memorization. After a brief introduction of the material, the students take an in-class concept test, then discuss their answers in small groups, and repeat the test. The critical thinking that is required to analyze the different answers that members of the group bring into the discussion dramatically improves the scores on these concept tests.

The remaining goals are addressed principally by presentations that the students make at the end of the semester, and a final paper based on these presentations. For these presentations the students have to research their topic (goal 4), and present it to the class (goal 2). A student's chosen topic can include not only physics, but engineering, other science disciplines, history of science, and social impact (goals 5 and 6).

ii. Phys 3550 Physics for War, Physics for Peace

This class is one component of the War & Peace cluster of the Summit cluster program, Engl 3550 being the other. As part of the Summit program the cluster is required to address all seven goals of the General Education Program.

11 Eric Mazur, *Peer Instruction, A User's Manual*, Prentice Hall (1997).

With students most of whom have not previously taken a physics class, the first third of the physics content is devoted to goal 1 (Subject Matter). This part of the course introduces the basic physics of the nucleus, radioactivity, and nuclear reactions. The remaining portion of the class covers the application of the physics to nuclear power and weapons, and their implications. A great deal of this material is interdisciplinary (goal 5) with links to Environmental Science, Biology and Health Science through discussion of safety aspects, politics, history, etc. Goal 4 (Information Retrieval and Evaluation) is addressed by assignments in which students research topics such the impact of the Chernobyl/Three Mile Island accidents and cold fusion, and try to balance the conflicting assessments which can be found on line.

The cluster ends with a capstone activity in which students are grouped into ten teams, and debate five questions related to the cluster. Students are responsible for researching their own material (goal 4 Information Retrieval and Evaluation), for assessing the information and organizing it into a debate format (goal 3 Inquiry and Critical Thinking), and for presenting it to the class during the debate (goal 2 Communication).

The cluster addressees goal 6 (Global or Multicultural Perspectives) principally through its English component which discusses literature and film related to the bombing of Hiroshima and Nagasaki, to the war in Vietnam, and to the Persian Gulf War, with material written from both the Western and non-Western points of view. This aspect of the cluster also earns the students credit for area G of the GE program.

iii. Astr 3000 Contemporary Astronomy

This class also has a student population most of whom know very little background information in either astronomy or physics, and a major portion of the class is devoted to presenting the subject matter material (goal 1).

The class takes as its theme the possibility if intelligent life elsewhere in the universe, and the distinction between the science and pseudoscience of that theme.

- goal 2 Communication and goal 4 Information Retrieval and Evaluation. Students research and write discussion essays on articles from popular journals such as Science, Sky and Telescope, Planetary Reports, etc.
- goal 2 Communication, goal 3 Inquiry and Critical Thinking, and goal 6 Multicultural Perspectives. Worldwide different cultures have their individual supernatural beliefs regarding extraterrestrial visitors. Some of these have no scientific basis; others are related to (now) well known

scientific events such as solar eclipses, comets (for example the Bayeux Tapestry), and the Chinese observation of the 1054 AD supernova. Students research the ‘evidence’ for pseudoscience observations such as extraterrestrial UFO’s, horoscopes, the Roswell incident, etc., and then present and discuss the scientific rationale for contradicting these popular beliefs.

- goal 5 Interdisciplinary Relationships and goal 7 Social Responsibility. The whole theme of extraterrestrial intelligence draws on many fields of science in discussing how scientists in the area of astronomy frame the question of what intelligent life means, and then use the definition to narrow the observational parameters to make the project feasible. Social implications of the allocation of financial and other resources are also discussed.

Assessment

Dr. Susan Mokhtari has been appointed the Program Assessment Coordinator (PAC) for the department, with responsibility for all the programs within the department, that is Physics, Physical Science, and Geology. Working in conjunction with the PAC committee the faculty of the physics program have selected the first objective of the first goal of the program (Students will have acquired a basic understanding of the core areas in physics including classical mechanics, electricity and magnetism, quantum mechanics, and thermodynamics) for class assessment. Dr. Rose Zhang will be assessing this goal in her research class (students enrol for Phys 4980 Independent Study).

The reader is also referred to the above section “Plans for the curriculum” for more reflections on the Physics Program.

a. Mission Statement

It is the mission of the physics program

- to offer a high quality major undergraduate degree, and to foster a life long interest in science.
- to develop in our students an understanding of the fundamentals and modern applications of physics, including the terminology, core concepts, and methodologies of the discipline.
- to develop each student's analytical thinking, problem solving techniques, and laboratory abilities.
- to prepare our undergraduate students for graduate school, a career in scientific research and development, or industrial work.
- to serve students in the rest of the university through high quality supplementary and support courses for other sciences and pre-professional programs.

- to provide majors and non-majors alike with an appreciation for the way the physical world works.

b. Student Learning Goals of the Physics Program

Graduates of the Physics program :

- will have a comprehensive knowledge of undergraduate physics, and master material in advanced courses.
  Objectives:
  1. students will have acquired a basic understanding of the core areas in physics including classical mechanics, electricity and magnetism, quantum mechanics, and thermodynamics.
  2. students will be able to solve physical problems in a wide range of contexts in physics.
- will think critically in analysis of problems in physics, including appropriate use of advanced mathematical tools.
  Objectives:
  1. Students will have an understanding of scientific method and how to apply it.
  2. Students will develop analytical skills and will be able to apply them to solve problems in physics.
  3. students will apply mathematical skills and reasoning to solve problems.
- will demonstrate the ability to work effectively in a laboratory environment, including the use of advanced technologies.
  Objectives:
  1. Students develop basic laboratory skills and become familiar with measurements and data analysis techniques used in physics and other physical sciences.
  2. students will apply mathematical skills and reasoning to derive quantitative results on which their conclusions are based.
  3. students will demonstrate the ability to evaluate the quality and usefulness of their data in reaching a conclusion.
  4. students will use scientific software to present and analyze their data scientifically.
  5. students will learn to participate and contribute effectively as a team member in an experiment.
- will have a strong command of the nature of oral and written communication and of intra-group interactions in the traditions of physics.
  Objectives:
  1. students will communicate scientific information in writing.
  2. students will demonstrate the ability to communicate scientific information orally.
  3. students will demonstrate the ability to search and find information in the physics literature.

4. students will demonstrate the ability to critically evaluate scientific communications (written or oral).
5. students will learn to participate and contribute effectively in a team discussion on physics.

c. Curriculum Matrix

Objectives with high relevance (H), moderate relevance (M), and low relevance (L) to listed courses. Assessment methods are indicated for high relevance	Phys 2250/60	Phys 2252/62	Phys 3010	Phys 3100	Phys 3320/30	Phys 3520
Basic understanding of the core areas in physics	H 1					H1,3
Solve physical problems In a wide range of contexts of physics	H 1			H1,3	H1,3	H1,3
Understanding scientific method and how to apply it						
Develop analytical skills and how to apply them to solve problems	H	H	H1,3	H1,3	H1,3	H1,3
Apply mathematical skills and reasoning to solve problems	H		H1,3	H1,3	H1,3	H1,3
Develop basic lab skills		H2				
Apply mathematical skills, reasoning ,and lecture material to derive quantitative results in lab environment		H				
Demonstrate the ability to evaluate the quality and usefulness of their data in reaching a conclusion		H2				
Use scientific software to present and analyze their data scientifically		M	M 2			
To participate and contribute effectively as a team member in an experiment		H				
Communicate scientific information in writing		H 2				
Demonstrate the ability to communicate scientific information orally					M4	
Demonstrate the ability to search and find information in physics literature						
Demonstrate the ability to critically evaluate scientific communications (written or oral						
				M		

1 = exam, 2 = lab. Reports, 3 = assignments/homework, 4 = presentation, 5 = observation, 6 = class discussion, 7 = short paper

Objectives with high relevance (H), moderate relevance (M), and low relevance (L) to listed courses. Assessment methods are indicated for high relevance. Basic understanding of the core areas in physics	Phys 4102	Phys 4250/52	Phys 4510/20	Phys 4530	Phys 4980
Solve physical problems In a wide range of contexts of physics		M1,3	H1,3	H1,3,6	
Understanding scientific method and how to apply it					
Develop analytical skills and how to apply them to solve problems	H2	H1,3	H1,3,6	H1,3,6	
Apply mathematical skills and reasoning to solve problems		H1,3	H1,3,6	H1,3,6	
Develop basic lab skills	H2	H5			
Apply mathematical skills, reasoning ,and lecture material to derive quantitative results in lab environment	H2	H2,5			
Demonstrate the ability to evaluate the quality and usefulness of their data in reaching a conclusion	H2	H2,5			
Use scientific software to present and analyze their data scientifically	M2				
To participate and contribute effectively as a team member in an experiment					
Communicate scientific information in writing	H2	H2			
Demonstrate the ability to communicate scientific information orally			M6		H4,6
Demonstrate the ability to search and find information in physics literature					H4,6,7
Demonstrate the ability to critically evaluate scientific communications (written or oral)					
Learn to participate and contribute in a team discussion on physics			M6		H6,7

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