Undergraduate Academic Program Review

Name of Program: Physics (B.S., B.A.)

Program Coordinator: Dr. Lok C. Lew Yan Voon, Chair
Department of Physics
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Program Location: Main campus

I. Program Mission

Program mission statement

The mission of the program is to develop individuals who have a good understanding of the fundamental principles and applications of physics and who have the capacity for critical and analytical skills.

Consistency with university mission

The above is consistent with the university mission of meeting the need for an educated citizenry dedicated to lifelong learning and service and by providing access to scholarship and learning.

Consistency with college mission

In parallel with the mission of the college, the department opens minds to science.

Consistency of goals, learning objectives with program mission

The current objectives of the B.S. program are

a. Employment as a practicing physicist in a laboratory environment.
b. Entrance to a graduate program in physics or a related field.

Extent to which program prepares students to "live and work in a global, diverse, and technological society"

The program prepares our graduates in both the fundamentals and the applications of a technological society. The general education component, course requirements in chemistry and math, and the availability of multidisciplinary electives prepare our

graduates for a diverse society. The research carried out by the faculty is international in scope and thus offers a global perspective and opportunity to our students. Furthermore, the presence of international students in our graduate program has been known to have an impact on our students' appreciation of the global society.

Extent to which program, through its curriculum and co-curriculum, fosters civic engagement and social responsibility

The program allows for these through the general education and free elective components.

Extent to which program fosters life-long learning

The physics program encourages and trains individuals in critical thinking and the further pursuit of knowledge and of diverse career paths.

Interrelationship with general education

General education, at 40 quarter credit hours, is a significant component of the undergraduate program.

Interrelationship with other WSU programs

The program has course requirements in many other subjects, including chemistry and math. There exists a dual program with mathematics. In addition, there are options within the B.S. program to allow a more substantial study of biology, earth science, and computing.

Community engagement

Both the B.S. and B.A. programs are well-aligned with the regional community in the Miami Valley. The greater Dayton region is an engineering community, without doubt the premier one in the State of Ohio. Our students have interacted symbiotically with local companies and Air Force Research Labs research groups at Wright-Paterson AFB through co-ops and internships. Many of these technical projects fulfill the BS program's senior research project requirement. The BA program has the goal of preparing potential high school physics teachers, of which there is an acute need in the state and nationally.

The faculty has, individually, demonstrated the positive match with community needs. Thus, many have acted as consultants to various research groups at Wright-Paterson AFB and to various companies and industries regionally. We also participate in numerous Science, Technology, Engineering and Mathematics (STEM) outreach such as school visits, presenting at the Honors Seminar of Dayton, being present at various science fairs such as Techfest, and organizing public talks by prominent physicists such as Lawrence Krauss (author of *The Physics of Star Trek*) and Sir Anthony Leggett (Nobel laureate).

II. Program Description

Brief history of program

The Physics Department since the inception of Wright State University has sought to offer traditional programs of study in physics and also be involved in diverse interdisciplinary programs that utilize physics. The department currently maintains 10 undergraduate programs of study or degree options.

- B.S. in Physics
- B.S. Dual Major Physics and Math
- B.S. in Physics: Geology Option
- B.S. in Physics: Biology Option
- B.S. in Physics: Computing Option
- B.A. in Physics
- B.A. in Physics: Physics Licensure Program
- B.A. in Physics: Physical Sciences Licensure Program
- B.A. in Physics: Life Sciences/Physics Licensure Program
- B.A. in Physics: Earth Sciences/Physics Licensure Program

The physics department maintains several programs or options of interdisciplinary nature with the Math, Earth and Environmental Sciences, Biology and Computer Science departments. The Physics Department is also closely involved in the Engineering Physics (EP) program administered from the Electrical Engineering Department.

The B.S. programs of study are founded on a traditional fundamental physics curriculum with topical or applied courses which broaden exposure to physics. The objectives of the programs have been to provide graduates with foundations to seek:

- Employment as practicing physicist in a laboratory environment.
- Entrance in a graduate program in physics or a related field

The curriculum is based on core requirements in several areas of physics which address the foundations of physics both theoretical and experimental. The table below shows the core physics requirements.

PHY 240,242,244	Introductory calculus-based Physics
PHY 260	Introductory Modern Physics
PHY 315,316	Instrumentation
PHY 371,372	Mechanics
PHY 322	Applied Optics
PHY 420	Thermodynamics
PHY 450,451,452	Electricity and Magnetism
PHY 460, 461,462	Quantum Mechanics, Solid State Physics, Nuclear Physics
PHY 494 or 499	Senior Projects

The senior modern physics sequence in particular provides the student with an underpinning to material preparatory for many graduate curricula. The Senior Projects course is a 2 to 3 quarter capstone sequence where students coalesce their understanding of physics principles into a research or design project. The written and oral presentation of their research requires the student to integrate various physics topics and develop critical thinking and communication skills. In addition to these core courses the department provides topical courses which broaden the view of physics and increase the ability to meet objectives of the program. Several of the courses are generally selected as electives by the graduates. The table below gives a sampling of topical courses.

PHY 106,107	Planetary Astronomy and Stars, Galaxies & the Cosmos
PHY 432	Lasers
PHY 440	Introduction to Nanoscience and Nanotechnology
EP 470	Introduction to Sensors
PHY 480,481,482	Introduction to Theoretical Physics

Two of the courses listed above have been introduced in the last 7 years. PHY 440 Introduction to Nanoscience and Nanotechnology was introduced in 2005 and EP 470, Introduction to Sensors was introduced in 2002. Both of these courses give breadth to the curriculum and were established to address interdisciplinary needs with the Engineering College.

The B.A. program was established in 2000 and was spearheaded by Dr. Bambakidis, then chair of the department, and departmental faculty member Dr. Basista. This was the foundation program for the physics and physical science licensure program. Currently we have 4 programs of study that provide licensure for science education. The B.A. program is similar to the B.S. program without the emphasis on preparatory material for entrance into graduate programs in physics. The modern physics sequence, Quantum mechanics, Solid State Physics and Nuclear Physics was removed from requirements as well as the last quarter in the Electricity and Magnetism sequence. The table below shows the core physics courses in the B.A. program.

PHY 240,242,244	Introductory calculus based physics
PHY 260	Introductory Modern Physics
PHY 315,316	Instrumentation
PHY 371,372	Mechanics
PHY 322	Applied Optics
PHY 420	Thermodynamics
PHY 450,451	Electricity and Magnetism

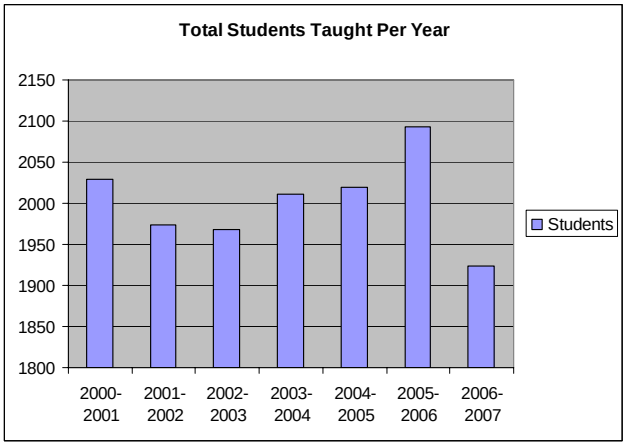
In addition, Physics courses were developed and refined since 2000 to address the educational needs of prospective science educators, several of the classes listed in the table below are requirements for many of the science education graduates and are additions or substitutions in the B.A. program.

PHY 346	Concepts and Application in Physics
PHY 445,446,447	Integrating Physical Science and Mathematics

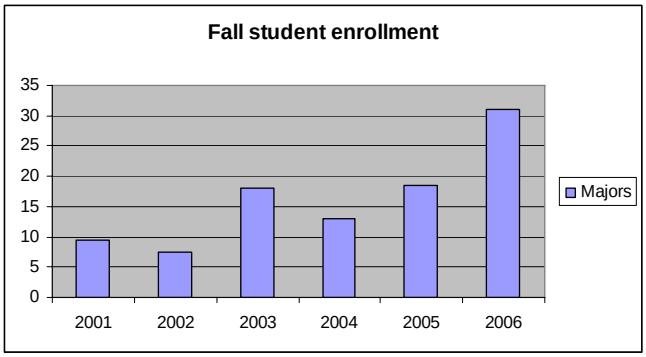
The department of physics is administered by a Chairman and the academic program is overseen by the chairman and the departmental undergraduate studies committee. Dr. Gust Bambakidis was chairman of the department from 1991 to 2004 and stepped down due to retirement. In 2004, Dr. Lok Lew Yan Voon came to the department as chairman.

Number of students served, majored and minored

The physics department carries a significant service teaching load, providing up to a year of physics for engineering, life sciences, physical sciences, and math students, physics content courses for education majors, and options for general education science courses. We have served an average of 2000 students in each of the last seven years (excluding summer teaching). The drop in 2006-7 is mainly due to a program change for early-childhood majors who switched from taking SM145 to SM144 (taught by chemistry).



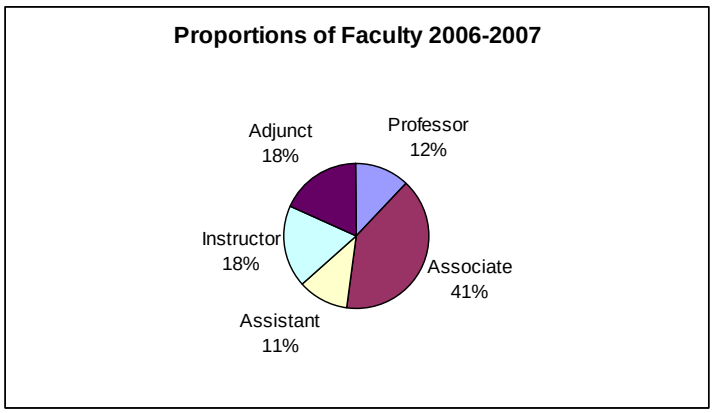
The number of physics majors has risen steadily over the last six years (all except one in the BS program), reaching up to 31 (including intending physics majors) in Fall 2006. The minor program is small with, on average, 1-2 minors at any given time.



Number of faculty and staff

The number of tenured/tenure-track faculty has been as low as 6.67 (as recently as 1999) and as high as 11.5. Currently we are at 11.17 FTE. A breakdown according to rank is shown in the chart below. We employ a few part-time adjuncts in any given quarter.

Traditionally, we have employed an instructor/lecturer on a regular basis. In the last two years, we have added a second instructor due primarily to the additional instructional needs generated by faculty buy-outs, sabbatical leaves and the teaching of college courses such as SM205.



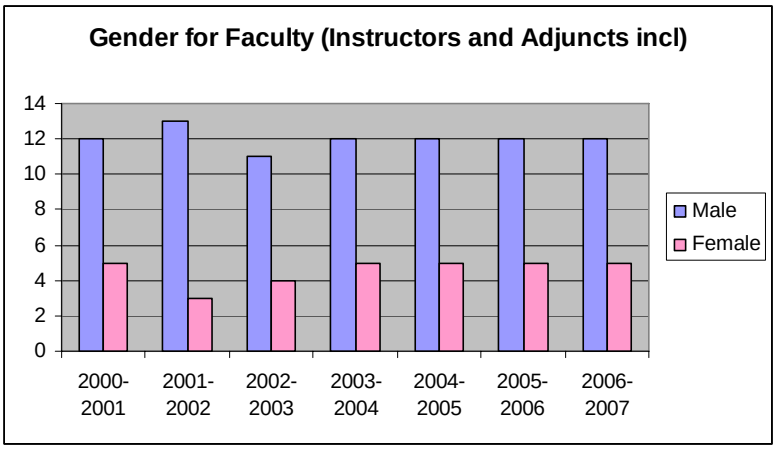
Since 2004, two new faculty lines in science education were added.

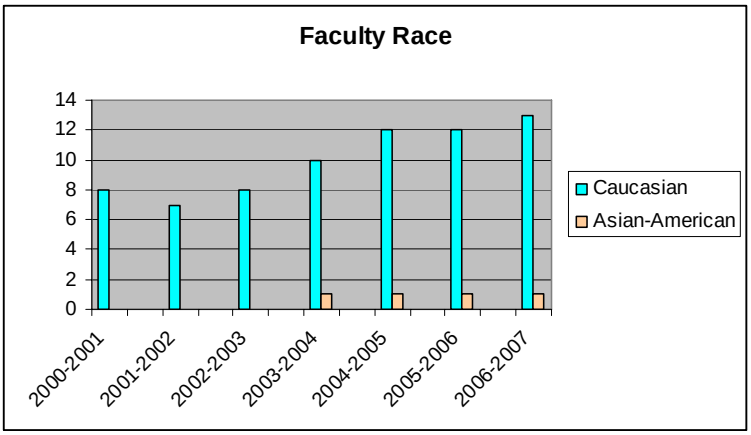
In addition to the above faculty, the department has a number of research faculty, some of whom have primary appointment with the Semiconductor Research Center at WSU.

The main office is staffed with 1.75 administrative staffs and there is one staff member who runs the introductory labs and the machine shop.

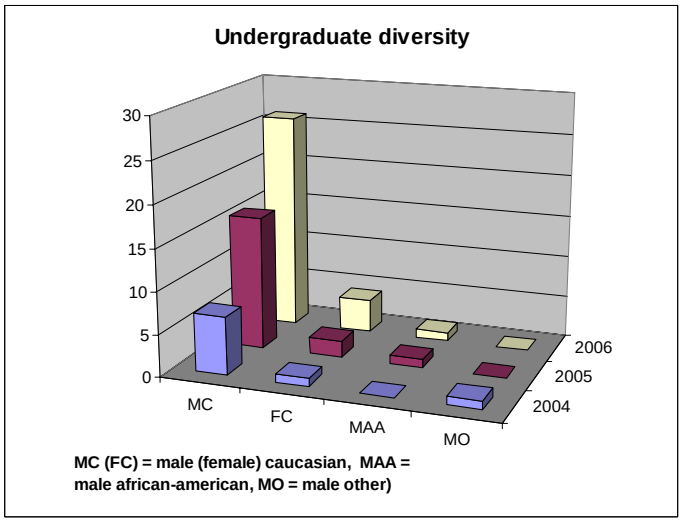
Diversity

The faculty is, by gender, more diversified than the national norm in physics. Of the 5 female faculty in 2006-7, one was an instructor, one assistant professor, two associate professors and one full professor. However, there is almost no ethnic diversity, with all but one full-time faculty being Caucasian. The staff is similarly diversified.





There is a little bit more diversity with the students, with 20% of the undergraduate student population being non-white-male in 2006.



Average class size

The department offers a variety of learning environments: large introductory lecture classes of 100 students or more, recitation classes of 30 or less, small classes for upper-level courses, lab/lecture combination classes of 30 or less, and introductory labs of 15 or less. According to data from the university institutional research office, the average class size is about 23 (compared to a CoSM average of 18.4 in 2005).

Budget

The total department budget has not changed in a number of years even though we have more faculty and more costs. The breakdown of the operating budget is given in the following table. The communications budget has been reduced over the years and is often in the red.

Category	Amount
Student employment	$32,741
Contracted services	$300
Supplies	$17,000
Travel	$4,160
Communications	$14,551
Maintenance & Repair	$2,500
Miscellaneous	$1,000
Total	**$72,252**

The department has consistently brought in more revenues than expenses, as can be seen in the following table. While the ratio has decreased over the last five years, most likely due to the addition of new faculty, the 2005-6 ratio of 2.2 is right about at the college average.

	2001-2	2002-3	2003-4	2004-5	2005-6	**2005-6 (CoSM)**
Revenue/Expense	3.010	2.876	2.414	2.190	2.175	**2.234**

Facilities and Equipment

The physics department is primarily on the second floor of Fawcett Hall, occupying most of that floor. A number of research labs are scattered around the campus including in the basement of Fawcett, the library annex and the M&M building. Specialized use spaces include a computer lab, a help room, a graduate student office and a machine shop.

The amount of dedicated space has remained fairly constant for the last five years. The total square footage is around 18,500, with about 15,400 s.f. for labs (teaching and research) and 3100 s.f. for office space. Currently, there is little room for expansion, whether it is faculty office, or research and teaching labs. We lack a student lounge for our majors. Of the 6251 s.f. identified as research space, only 23% has been rated as being superior by the occupants, 41.5% has been rated satisfactory, and 35.5% has been rated as deficient.

In addition to office equipment in the main office, equipment in the machine shop, and the computers in the computer lab, there are a number of major pieces of equipment in the various research labs such as Van DeGraff accelerators and electromagnetic sources from the UV to Terahertz.

III. Program Effectiveness

Achievement of student learning outcomes

No comprehensive assessment of the service courses had been performed in the past.

In 1997, a survey of alumni revealed that, of the 19 who responded, in answer to the question

- How well did your degree prepare you for graduate school?

  None rated their preparation as inadequate. A few indicated the need for additional courses such as more quantum mechanics, mathematical methods and upper laboratory courses.

- I had enough preparation in this area

  1. Agree 2. Disagree 3. Not applicable.

Areas	(1)	(2)	(3)		(1)	(2)	(3)
Mechanics	17			Lab. instrumentation	15	2	
Thermal Physics	14	1	1	Research Project	14	3	
Atomic	13	3	1	Special Relativity	11	2	3
Nuclear	13	3	1	General Relativity	7	5	4
Quantum Mechanics	15	1	1	Mathematics	15		2
Solid State	10	5	1	Computer Programming	15	2	
Theoretical Physics	12	1	2	Engineering	9	3	4
Optics	17			Chemistry	10	3	4
Electricity and Magnetism	17			Biology	7	5	4
Lab. methods and Techniques	17						

Thus, most of those who responded about their learning did so positively.

The assessment of the program from July 1, 2003 – June 30, 2004 was based on the following outcomes:

1. Cognitive knowledge
2. Understanding research
3. Communication

The measures used were based on the required senior projects. The findings were favorable for all three outcomes. The students expressed a need for improving our student computer laboratory. In the following year, the laboratory was upgraded by replacing the two existing PC's with six new or upgraded ones. During 2004-2005, internet accessibility was installed. In 2006-7, with funds from the college and as part of a state Wright Center of Innovation grant, the lab was completely renovated with new computer desks and chairs, 10 new PC's, and a 65 in plasma screen.

There were no graduates from either program in the period July 1, 2004 – June 30, 2006.

The assessment from July 1, 2006 – June 30, 2007 was based on the following the learning outcomes for the program:

- Sound knowledge of several core areas of physics, such as mechanics, modern physics, electricity and magnetism, thermodynamics, optics and instrumentation.

- Ability to understand and conduct research in physics a level appropriate to an undergraduate major.
- Ability to communicate research results effectively.

There were 3 graduates. The findings are given in the table below. In brief, the program was considered effective in achieving the learning outcomes.

	Senior Project Presentation (avg. rating across students)	Upper Level Coursework (avg. rating across students)
Knowledge	3.1 / 4	3.25 / 4
Research	3.1 / 4	3.25 / 4
Communication	3.0 / 4	NA

Student retention and graduation rate

As measure of retention we have looked at the four year retention for the students declaring physics as major and students declaring intention to physics as major. According to data from the university institutional research office, those students declaring physics as major between Fall 1999 and 2004 total 6 students with 2 students retained in physics and 3 leaving the university. The students with intending declaration to physics numbered 13 with 1 retained in physics and 4 leaving the university. These data are based on the 14^{th} day in the Fall quarter. There have been a number of transfers (into and out of the program) in the other quarters.

According to data from the college, the retention rate in 2005-6 was 33.3%.

Placement of graduates

The low response rate from alumni surveys do not allow us to provide an accurate picture on the career path of graduates. Available data do point to the majority ending up with a career in STEM, after obtaining a graduate degree either at WSU or elsewhere.

A number of our students do benefit from their internships with area high-technology companies and the Air Force Research Lab either directly or indirectly.

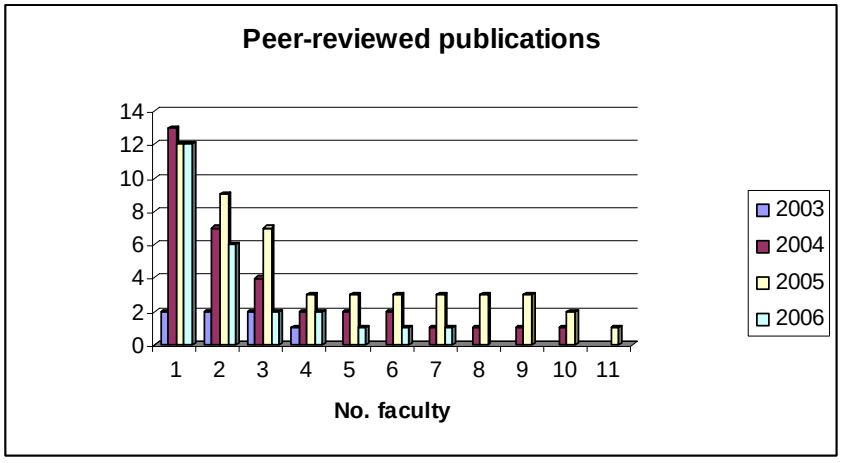
Teaching effectiveness

Faculty teaching effectiveness has been evaluated primarily using the university-approved student evaluation form, with an annual peer evaluation for untenured faculty. Department-wide data reveal no significant deviation from the college-wide distribution.

Faculty productivity

Tenured and tenure-track faculty, in addition to teaching and service work, have to carry out scholarship. The data to be presented represent those faculty plus one research faculty who is fully affiliated with the department; note that the number of faculty has increased slightly from 2003 to 2006. In 2003, only 4 faculty published papers, with a total of 7

papers among them. In 2005, all 11 faculty published for a total of 49 papers, though 3 faculty accounted for more than half the total. In 2006, 7 out of 11 published a total of 25 papers.



External funding has also increased substantially from approximately $200,000 in 2000 to close to $1.5 million in 2006.

Integration of technology into curriculum and instruction

Coursework in Physics incorporates technology in the classroom in a variety of ways. Virtually all classes use electronic media of some sort for transmitting course materials. Electronic reserves through the library, WebCT, and Wings Express all provide means of giving students access to syllabi, electronic presentations, assignments, readings, grades, on-line quizzes, chat rooms, and more. This has become the norm for most classes, and has been assisted by the increasing access to computers and wireless access on campus and of classrooms across campus that are equipped for multimedia. The department also maintains a dedicated classroom for computer access with installations of software such as Mathematica, Matlab, Igor Pro, Labview, and other physics related software, used in class for demonstrations or out of class in assignments.

In laboratories, students use a diverse array of instrumentation. Spectrometers, optical construction breadboards, physical transducers, lasers, electromagnets, electronic breadboard/design stations, computer aided data acquisition stations and others are a part of the undergraduate laboratories associated with many of our classes. In senior projects the students are often exposed to research instruments in the department such as the Van DeGraff accelerator, electromagnetic sources from the UV to Terahertz, and state of the art data acquisition systems.

Description of how program ensures that it is always current

For some of our courses, periodic review by accrediting agencies (ABET accredits the Engineering Physics Program) provides external assurance of currency. Additionally, a departmental seminar program brings in experts from across the country, nearly every other week of the academic year, to speak on their research. Most faculty attend and

undergraduate students are also invited to attend these seminars, which provide insights into current research in physics. To a large extent, we rely on faculty to remain current in their fields and maintain individual courses with current updates. Most faculty attend and present at national and international conferences which enables them to keep abreast of new research and emerging topics in their fields. Limited opportunities exist for faculty professional development and a few have availed themselves of those opportunities.

Comparative advantage

Advantages offered by our programs include the ready access to research faculty for undergraduate students, including opportunities to work in research laboratories alongside faculty and graduate students. The close proximity of the Air Force Research Labs and commercial R&D companies in the Dayton area also enable many students to develop co-ops and off-campus senior projects at state of the art research facilities.

Our undergraduates benefit from an interdisciplinary environment in a number of ways. First and foremost, they share many courses with Engineering Physics majors. Second, a number of recently-introduced courses such as Sensors and Nanotechnology put them in a multidisciplinary class. Third, some of their upper-level classes are combined with graduate-level ones, allowing the undergraduates to interact with our MS students.

IV Program Needs/Areas in Need of Improvement

The Department of Physics offers a strong program of education and research opportunities. However with the increased emphasis on STEM degrees, departmental collaborations like the Engineering Physics program, Advanced Technical Intelligence Center (ATIC) certification program and the Science Education program, additional courses may need to be developed and offered. In addition, the physics faculty has recognized the need to offer additional courses for the majors, in order to align more with the curriculum offered by comparable schools. These current and future developments will increase the load on current physics faculty and additional faculty members may be needed.

The various options within the BS program and the BA program have had very low enrollment since inception.

In order to increase the number of majors and the retention rate, it is important that we improve recruiting, student advising and program assessment. This is a time-consuming task that will increase the load on current faculty. Reduced teaching loads may become necessary in which additional faculty members may be needed.

In terms of facilities, over 35% of current research space has been rated as deficient by the occupants. Given that this would impact undergraduate students through the quality of the research experience offered, there is a need to improve the infrastructure.

V Proposed Improvement Action Plan

The department will continue to improve communication between faculty, staff, and students predominately by maintaining and improving the departmental website. Increased efforts at outreach via improved participation at science fair events and school visits are being implemented. An improved website will provide a powerful tool in recruitment of undergraduate and graduate students by relating the activities of faculty, current students and alumni. Meetings with the Department Chair will be offered on a regular basis to provide a forum for discussing courses, scheduling and special events within the department. The department would like to increase the faculty and alumni interaction with the student organization, Society of Physics Students, providing educational and social relations which will better educate the students about a variety of career and educational opportunities. The department has implemented an alumni speaker series and wishes to expand the opportunities of former students speaking with current and future students. Finally, a model of mandatory advising is being developed. All of the above efforts will necessitate additional staff resources or faculty buy-outs for effective implementations.

Proposals currently in development have lines for research faculty and science education faculty as new collaborations are developed. Perhaps the most important personnel need is for additional teaching assistantships. Additional teaching assistants would benefit both the quality of our teaching and the quality of our graduate program which is inherently linked to our undergraduate program.

The undergraduate curriculum has been under study for a number of years and gradual changes will continue to be implemented. Ultimately, the goal is to arrive at more course offerings at the senior level. This might require restructuring some of the current course sequences.

A master plan for laboratory renovation might be necessary in order to address the numerous deficiencies. A current action plan that has been working has been to fund the upgrades through faculty grants and new collaborations with outside entities such as the Air Force Research Laboratories.