# DEPARTMENT OF PHYSICS
# &
# ENGINEERING

IN-HOUSE REVIEW

**Point Loma Nazarene University**
**1999**

# PHYSICS/ENGINEERING REVIEW

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# I. PRESENT STATE OF THE DEPARTMENT

## A. General

The Physics/Engineering department was essentially founded and given a sure footing by Dr. Garth Morse some 30 years ago. As the university grew both physically and financially, faculty were added. By 1986, three Ph.D. physicists were involved with the program full time. The university has also during the past 15 years tried to generously support the department with improvements in facilities and equipment. The result of this departmental evolution has resulted in students with improved exposure to physics and a resulting greater professional maturity.

The department presently offers an AB degree in Physics and an AB degree in Engineering Physics. The Engineering Physics major is a less flexible major demanding about 10 more credit hours of required course work. This difference in course work revolves around a number of engineering courses that are offered by the department. Also, the department services a pre-engineering program for those students desiring to complete an engineering degree at another university.

The Engineering Physics degree is the more popular of the two degrees. An entering freshman class will consist of approximately 15-20 students. More than two-thirds of the class will be either pre-engineering or engineering physics majors. The department will graduate 2-6 students per year with the majority being Engineering Physics majors. In Appendix A are data indicating the number of graduates for the past 5 years. Also included in this data are details concerning FTE, faculty loads, budgets, etc. for that same time period.

B. Faculty & Staff

The physics/engineering physics faculty consists of Dr. Ken Aring, Dr. Dee Puntenney, and Dr. Keith G. Walker (chair). A vita is included in Appendix B for each of these gentlemen. Each has been in Christian education for over 25 years and each has a proven commitment to the principles of Christian education and the value structure of the university. These faculty members bring to the department diverse strengths and abilities.

**Dr. Ken Aring** has a passion and expertise to teach general education that integrates one's faith and the sciences. His labor in this area is one of commitment to the heart of a Christian education. Dr. Aring also helps service the beginning physics and engineering courses as well as several advanced courses (Thermal physics, Quantum Mechanics II). He has been on the faculty since 1972.

**Dr. Dee Puntenney** has been at the university since 1985 and brings to the department a broad expertise in biology, chemistry, and physics via his degree in Health Physics. Dr. Puntenney also strengthens the department with his strong commitment to the building of community among the students of the department. Dr. Puntenney is not only committed but also effective in the recruitment and retention of students...a service that has proved invaluable to the department. Dr. Puntenney services a general education physical science course, beginning physics and engineering courses, as well as several advanced courses (Analytical Mechanics, Nuclear Physics).

**Dr. Keith Walker** first came to the university in 1986. Dr. Walker brings to the department experience in undergraduate research. Dr. Walker helps service a

general education physical science course, beginning physics courses, and advanced engineering and physics courses (Electromagnetism, Electronics, Computer interfacing, Quantum Mechanics I).

Each of the above faculty are in the age range of 50-60 years. This means that changes are in store for the department in the next decade as the present faculty contemplate retirement. How the administration anticipates and handles these transition times will be important to the health of the department.

C. Curriculum

The curriculum must function around three areas: General Education, Service courses, and the Departmental Majors.

The General Education portion consists of two courses: Earth Science and Physical Science. These two courses will attract approximately 200 students per year and their review is subject to the General Education Committee of the University.

The department offers four (4) courses that service other majors:

- General Physics I & II, which has very limited use of calculus.
- University Physics I & II, which uses the calculus heavily.

These courses are utilized by students in allied health areas, pre-medical, biology, physical sciences, and pre-engineering. The upgrading of requirements by the biology department in requiring all its majors to take calculus has brought into question the necessity of General Physics. Presently, though taken by a number of pre-meds and biologists, its only real need is to service

the allied health areas. All other majors could easily option for the University Physics course which requires extensive use of the calculus.

The department offers a curriculum for its majors that would be considered standard relative to most universities of our size. However, as with all universities, the physics curriculum has been 'under attack' from the need to supply students with certain skills that were deemed non-essential 20 years ago. It is imperative that physics graduates have a degree of skill in digital electronics, computer programming, and the utilization of computer technology to control instrumentation and log data. This expansion of skills has come at the expense of math, chemistry, and physics courses. It has even become increasingly difficult to include General Chemistry in a physics/engineering physics curriculum.

The curriculum must constantly be scrutinized to insure its integrity in physics and also viability to the present scientific and social culture.

D. Facilities

The department occupies approximately one-half of the second floor of the Rohr Science Building. This amounts to about 2800 $ft^2$. This space allocation is presented in more detailed form in the following paragraphs.

Offices—700 $ft^2$

There are three faculty offices. They reside adjacent to one another and allow for good communication and camaraderie. The physics department secretary resides in the Math department and is a shared resource with the Math/CS department. No workroom is available for the Physics department.

Storage—100 ft$^2$

There is only one small room in the department that is given entirely for storage of equipment, etc. Most equipment is stored in cabinets located in the laboratories. Note: The administration has recently allocated around 150 ft$^2$ of storage at a temporary storage area in the bottom of the Fine Arts facility.

Machine Shop – 300 ft$^2$

In 1988, the Physics Department received some external funds and initiated a machine shop. This small shop (100 ft$^2$) contained a small lathe and milling machine. From this unpretentious start, the machine shop now has the beginnings of a mature shop with professional grade machines. Much of this advancement has been due to the efforts of Dr. David Brown of the biology department. Several years ago the administration made available a much larger room in the basement of the science building. This machine shop trains selected physics/engineering physics majors in machining techniques and procedures.

Intermediate Lab—100 ft$^2$

A small area has been allocated for the intermediate laboratory. Included in this area are storage cabinets containing most of the equipment for this laboratory.

Research/Advanced Lab—300 ft$^2$

A recently constructed lab facility has been provided by the administration. This lab is presently being used for

two purposes. It houses the equipment and research facilities for Atomic and Molecular Physics as well as serving as a basic facility for the Advance Physics Lab. It is well supplied with storage cabinetry.

Lecture/Lab Room #1—700 $ft^2$

In 1987, the administration granted the Physics department monies to remodel several laboratories. This laboratory was remodeled in such a manner as to serve a dual purpose—classroom and laboratory. As a classroom it can service about 20 students and as a laboratory facility it can handle 10-12 students. Such a situation was required since the campus is painfully short of classrooms. This room serves mainly the General Physics and University Physics lectures and labs. It also services a portion of the laboratory for the general education Physical Science course.

The remodeling of this lab/classroom was not a complete remodeling and cosmetic work needs to be done on the room.

Lecture/Lab Room#2—600 $ft^2$

As in Lecture/Lab room #1 above, this room was remodeled to serve two purposes. It presently serves as classroom for the advanced courses and shares it laboratory functions with Intermediate Lab, Advanced Lab, Special Projects Lab, and the two electronic course laboratories. As a classroom it can service 12 students and as a laboratory it can handle about 8 students. As in Lecture/Lab Room#1, cosmetic remodeling is needed desperately.

Lecture/Lab Rooms #1 and #2 are utilized quite heavily and have proven a wise investment by the administration.

E. Equipment & Laboratory Classes

The department is slowly but surely becoming better equipped. The administration has been allocating $3000-$4000 each year to the dept via the capital equipment fund. This has been generous since the capital equipment fund is quite limited and the demands upon it are quite high. Our departmental budget has been able to provide needed supplies and small equipment items. The department has been ably supplied by the Information Technology Services with computer resources in the laboratory and faculty offices. We presently have a 333 MHz PC at most laboratory work stations and each faculty office is equipped with a relatively new PC.

The research laboratory has over $100,000 worth of equipment, most obtained by research grants. Much of this equipment serves several purposes by also providing a resource for the advanced laboratories.

The result of this administrative support coupled with departmental effort has led to an improvement in the laboratory experiences obtained by students.

The following labs are supported by the department:

- Physical Science Laboratory (28 sessions per year)
- General Physics Laboratory ( 28 sessions per year)
- University Physics Laboratory (28 sessions per year)
- Intermediate Laboratory (14 sessions every two years)
- Advanced Laboratory (14 sessions per year)
- Analog Electronics Lab (14 sessions every two years)
- Digital/Interfacing Lab (14 sessions every two years)

For the past several years the department has gradually added lab experiences in the General Physics and University Physics Labs that involve use of the computer to control the experiment, log the data, and present the results of analysis. The equipment to do such experiments is obtained from PASCO Laboratory Equipment Co. The department has found their equipment quite original, reliable, and affordable.

The PC has found its way into the Intermediate and Advance Labs where it is used for a variety of purposes ranging from multi-channel analyzer and digital storage scope to a generalized controller and data taker. It is the hope of the department to continue this process of computerization in the labs. It is also a concern of the department, especially in the use of the PASCO equipment that the physics of the experiment and the fundamental purposes of the experiment are not hidden by the ease of computer activity and 'cleanliness' of the printout. An area of increased focus by the department in these introductory labs should be the arrangement of the experiment and its subsequent questions so as to force questioning and analysis by the student.

F. Assessment, Strengths, and Weaknesses

1. Assessment

The department formulated a survey instrument and mailed this survey to over 50 alumni, most of whom have graduated in the last 10 years with a degree out of the Physics department. Of this number, 22 responded. Appendix C contains the survey, summarization and analysis of the responses. This appendix also contains a listing of recent graduates and their history after leaving the university. The salient feature that the department extracted from this

survey was the high praise the alumni had about their experiences in the department and the education they received. From this data it behooves the department to not be too radical in changes of its present modus of operandi and the curriculum that it offers.

2. Strengths

a. Mature faculty

As mentioned previously, the three faculty in the physics department are each well established in the teaching profession with a large number of years of experience. This experience proves valuable as the faculty interact with students and their individual problems. This experience also enables the faculty to insure that students receive the proper material in their journey through the department. The faculty work together quite well and have little, if any, problems in setting policy and assignments. Each of the faculty have their individual strengths and these strengths are known and respected by the other faculty in the department.

b. Student-faculty community

The students in the department form a rather tightly bound group. They readily help each other in the various battles that confront a physics/engineering physics major. The classroom situations are relaxed and friendly, students showing respect for the teacher as well as the subject matter. Much of this strength certainly results from the character of the student-pool that the university recruits from.

The department has seen a growth in the number of female physics majors in the last several years.

What has been especially gratifying is the way a spirit of community has evolved between the male and female majors. The development of a significant ratio of women-to-men has had a positive influence upon the department as a whole and the classroom in particular. It is the department's desire to provide the needed opportunities and environment for women to flourish in the physics program for we definitely believe it results in a much stronger and viable department.

The faculty has nurtured these attributes and created an atmosphere that allows student-faculty interaction in a most admirable manner.

c. Undergraduate research experiences

A research program is presently available in the field of Atomic and Molecular Physics (Electron Excitation Cross-Sections of the Inert Gases). This program has provided a number of students experiences in the laboratory that are not often found in a typical university of our size and nature. In this experience, a student becomes well versed in very high vacuum technology, electron-beam production, and detection techniques in the ultra-violet, visible, and infrared. The experience a student acquires in the use of lock-in amplifiers, photon counters, liquid nitrogen cooled solid state detectors, monochromators, photomultipliers, ion-pumps, etc. prove invaluable in promoting maturity in the laboratory.

d. Integration of Faith & Science

Largely through the efforts of Dr. Aring, the department provides its majors insights into

questions regarding ones Christian faith and how it relates to scientific facts and investigation. The department utilizes two vehicles to promote this goal: Departmental chapel and the required course, Physics 495, Seminar in Physics.

3. Weaknesses

a. Lack of youth on department faculty

As so often occurs, strength has a way of also becoming a weakness. As mentioned, all three physics faculty are in the 50-60 age range. As such, all three faculty in many ways have a common mindset and viewpoint. A youthful diversity with its accompanying enthusiasm, 'wildness' of thought, and unending activity are missing from the department. Lacking this ingredient limits the excitement and spawning of new ideas and new ways for the department and its majors.

b. Lack of an Engineering Mindset

Life experiences and professional maturity in a given area of study, governs how one teaches. These life experiences prejudice a faculty member's choice of texts, problem assignments, and the approach to solving problems. For example, Dr. Keith Walker teaches digital electronics and computer interfacing. He does so from the point of view of a research physicist whose experiences have been in atomic and molecular physics laboratories across the country. In many ways this is beneficial and has resulted in the Chemistry department sending a number of its majors to the course. But, unfortunately, since all departmental faculty are physicists each course and lab experiences in the

curriculum feel the prejudices of a physics mindset. If the department is offering an engineering physics degree, which has high demand, it should obligate the department to introduce viewpoints that come from an engineering mindset and its associated 'spirit'.

This lack of engineering background shows itself in another more direct manner. Engineering 111 and Engineering 112 are two beginning engineering courses that focus on drawing and the CAD experiences. These are skill-oriented courses and their development is very sensitive to the experience of the professor. None of the present Physics faculty have the required background or skills to develop these courses so that they are current in software and hardware, let alone pedagogical approaches. One of the physics faculty has worked diligently at presenting these courses in a proper manner but has felt his own inadequacies in this area. The Physics faculty feel keenly the weakness of these two courses and the need to provide them with the proper expertise and the subsequent revitalization of content and presentation.

c. Curriculum with direction

The present curriculum provides a good foundation for a major in physics or engineering physics. There are, however, a few areas that are lacking in the curriculum. For example, a course in basic circuit analysis has yet to be incorporated into the engineering physics degree. But essentially, the present curriculum covers most fundamental areas of physics. What is wanting is a curriculum constructed so that it:

- Accomplishes purposes that have been explicitly articulated by the department.

- Takes advantage of the expertise and interests of the present faculty.

  This is not surprising since the last time the curriculum was reviewed and changed occurred during the conversion from a quarter to a semester calendar in 1992. This was done at a difficult time for the department. The department was short one faculty position and was having trouble finding a replacement. Also, one of the two remaining faculty members was in the initial phase of a serious physical difficulty that rightly absorbed his attention. This left a single faculty member to fabricate the curriculum conversion while the department was understaffed and in a state of uncertainty about the future. Coupled to the departmental confusion was the focused attention of the administration on credit-hour and faculty-load equivalencies in the conversion. Given the circumstances, the present curriculum is quite commendable and has served the department admirably for the past 7 years.

  There are obvious deficiencies in the program, however. The present curriculum requires no computer programming classes even though that skill is assumed in several of the advanced courses and almost all future employment will require this skill. Presently, it is possible for one to obtain an AB in Physics with only 4 hours of Chemistry. There is no thorough presentation to engineering physics majors of circuit analysis and the use of complex variables in such analysis even though we tout that the area of engineering that we focus on is electrical. The resolution of these deficiencies is quite challenging, if not impossible, given the weight

of general education that is present at Point Loma Nazarene University.

d. Student work in the Department

Presently, there is no constructive effort in generating a plan by which students are actively involved in improving the state of the department. The department has limited itself to providing lab assistant and paper grader positions. This usually involves about 5 students. The typically hourly contribution of these students is about 4 hours/week/student help. Such positions are necessary to adequately operate the labs and some of the larger general education courses. What is missing is student involvement in the general maintenance and upgrading of the department's facilities and equipment, thereby producing a partnership between the department and the students that continues beyond graduation. Creation of this involvement is sensitive to circumstances and pressures upon the students that are outside the control of the department. Nevertheless, a plan should be constructed to try and generate such an engagement between the department and its students.

e. Space Limitation

As previously mentioned, the physics department has two large areas that serve as both lecture room and laboratory. Administratively, this is optimum utilization of space. Pedagogically, it falls short of the ideal. What presently occurs is a constant movement of equipment into and out of the room. The ability to set-up lab stations and create new

techniques of lab instruction has been eliminated. These two rooms ironically seem to lose an identity and become ambivalent in purpose in the minds of faculty and students.

The department is severely hampered by the lack of spaced for proper development of laboratory opportunities for the advanced students. First, the nuclear physics laboratory space is lugubriously inadequate. The nuclear physics lab room is so small that no more than two-three students and the professor can semi-comfortably reside. Secondly, the present research lab serves a dual purpose by housing the advanced lab course. Casual observation of the room will easily display a very crowded facility. The department seriously needs an expansion of the Nuclear Physics lab as well as the creation of a research lab in order that the present research facility can be fully utilized by the advanced laboratory.

Secondly, it is impossible to set up laboratory situations in the upper division labs that have a 'noise component'. For example, presently the research laboratory has to also house equipment used for obtaining spectroscopic data in advanced lab. This system should be stationed in the upper division laboratory space but cannot because it utilizes a vacuum pump which is continuously running; hence, the inability to hold a class in the room at the same time the equipment is up and running.

f. Storage facilities

A physics department needs storage. The lack of such a facility costs the university more money than

they realize. Not having storage requires the department to 'rid itself' of various items that are only used occasionally. When the next occasion for the use of such an item occurs, it is then re-purchased with the subsequent overhead of lost faculty time. Certain pieces of equipment are completely functional but may only be found useful several years in the future. These items are many times very expensive to repurchase. Or, as often as not, the equipment is obsolete and may or may not be functioning, but the parts that can be salvaged as the need arises result in large cost savings.

a. Internships and Summer Experiences

The department believes that experiences in the scientific and technical arena that exist outside of the university are extremely important in promoting professionalism in a student. There are basically two avenues available for delivering such experiences: Internships at various businesses involved in technical and scientific work and Summer Experiences at government labs or universities.

The department has failed to emphasize and promote either of these possibilities in the past. However, measures are beginning to be taken to eliminate this failure. The department has begun to encourage students to investigate and participate in summer experiences at government labs or universities. We are beginning to have success in this arena. This past summer (1999), there were three juniors who were involved in external summer programs. One student was involved in theoretical studies (quantum cryptology) at the Los Alamos Laboratory. A second major was selected to participate in an Undergraduate Research Experience at Brigham Young University (optics). A

third junior was chosen to spend the summer at the FBI labs in Washington, D.C.

These experiences are deemed superior to internships for several reasons. First, internships during the year are a significant diversion of the student's time and attention. Physics and Engineering Physics majors have little room for maneuvering time-wise their schedules. Second, the subtle subversion of an internship upon the academic goals of a student is a real danger. The attractiveness of real money for real work upon graduation from the undergraduate institution can divert the student from further academic preparation. The reason such a diversion is troublesome arises from the department desiring to only place its good students out in the public workplace. To lose these promising professionals from graduate programs to the 'now' of the dollar is unsettling.

This is not to say that internships are bad, but the department feels that summer experiences provide a better situation for the student to mature and aspire to high goals.

## II. DEPARTMENTAL PROPOSALS AND FUTURE PLANS

A. Curriculum

Whatever changes are stipulated for the curriculum, we remain aware that our alumni are, for the most part, happy with the education that they received in the department. Also, it must be remembered that most of those respondents went on to graduate school or a job utilizing their technical skills and their comments are not made in a vacuum.

The curriculum for a physics major must be faithful to the basic tenets of a physics education: Mechanics, Thermodynamics, Electromagnetic Theory, Modern Physics (quantum theory, relativity, nuclear, and particle physics), and lastly, Laboratory Experiences. That same curriculum must be able to incorporate an adequate amount of mathematics as well as skills that the present scientific community deems appropriate (electronics, computers).

The physics department is proposing:

- A curriculum modification.
- A new program (Physics and Computing).
- An added degree (Bachelor of Science) for the departmental majors.
- Modified requirements for the AB degree in physics.
- Introduction of a minor in Physics.

The proposed curriculum does not eliminate all the deficiencies that have been put forth but does try to better the present state of the department and answer some of the problem areas.

Appendix D contains the proposed new curriculum as well as a typical four-year program for each of the possible majors and degrees offered by the department. Course syllabi are housed in appendix E. The department faculty has reviewed each of these syllabi for content and course integration.

The department believes this curriculum begins to attack some of the weaknesses discussed previously and meets the goals set forth by the department. It provides opportunity for each faculty member to engage in course(s) that are in his or her areas of interest (Aring-Solid State, Puntenney-Nuclear, and Walker-Atomic & Molecular, Robotics). It is also adjusted into

accommodating interest and demands in the scientific and technical community by introducing a new program (Physics and Computing). The changes have fundamentally been minor in the overall course content and offerings, insuring a continuing quality of preparation for graduate work and/or employment.

DISCUSSION:

1. Rationale for the BS degree

The department presently offers only a Bachelor of Arts degree for its majors. In reality, these majors are more equivalent to a typical Bachelor of Science degree found at most universities. One may wonder what the true meanings are between the degrees. Below we have extracted paragraphs from the web pages of the Physics Departments of several University of California schools that will perhaps illuminate how these two degrees are generally viewed by the academy.

From the UCSD Physics web page:

> While the BA program is suitable for students who pursue a terminal degree in physics or use it as a preparation for other professional careers, it is not intended for those who wish to proceed to the Ph.D. in physics. The latter should enroll in the BS program.

From the UCSB Physics web page:

> There is great flexibility in paths to a degree in physics at UCSB. The standard program, which is in the College of Letters and Science (L&S), leads to either a BA or BS degree. The BS program is for those aiming for a career in physics, while the BA is a more flexible program allowing more courses from other areas.

What is quite evident is that the AB is restricted to those individuals whose undergraduate degree in Physics is a terminal degree in Physics. Its purpose

is for those who plan to execute their careers in other fields but feel the rigor and philosophy of Physics will prove beneficial to them. Examples of such students would be those who would go on into medicine, law, business, philosophy, education. It is interesting to look at Harvard. Harvard graduates one of the largest undergraduate classes in physics in the nation...around 70 students. Of these, only about half go on in physics. The remaining 50% seek careers in other areas. Such a 'change in direction' by these students is not by default but by design upon entering the institution. In summary, the necessary requirement for the AB degree is flexibility in the degree requirements by providing a relative large number of electives.

The BS degree is for those individuals desiring a career in the sciences and seriously considering graduate work. This degree would obviously have less flexibility.

The department is proposing these two degrees for PLNU; thereby, reflecting a consistency with the more general academy in the meaning of an AB degree. By restricting the AB degree to this design, the department can be flexible in servicing such students and not forcing all students into a standard mode. It is imperative that the department continues to offer and support a degree that enables a student to be prepared for graduate work in the sciences. The results of the departmental survey found that the department has been successful in fulfilling this obligation and the department desires to not lose this tradition. The BS would reflect such a desire and reveal to the academy the intent of a student.

As it now exists, a department major with a BA degree is initially suspect to graduate programs

and/or industry as to what their preparation and goals were in the undergraduate experience. It is also important to note that both the BS and BA degree require the same general education core, insuring that the fundamental tenet of the university's liberal arts education has not been compromised.

2. Discussion of Program: Physics and Computing

The computer has entered the fabric of people's lives and most certainly the life of the academy. One ramification has been the development of a new area of high demand in physics which integrates computer science with the physics. Its rise has been meteoritic and that rise has not been without validity. More and more, the scientific community is utilizing the increased power of the computer to model and simulate phenomena that would require large number of man-hours in laboratory time or were even thought impossible to attempt in the laboratory. The improvement in time, effort, and accuracy in determining outcomes of interacting events has revolutionized many areas of the scientific and technical community.

Students have responded to the much-publicized need for expertise in the utilization of the computer for the performance of tasks, whether in the business community or the science lab. Hence, the department each year finds a significant number of our entering freshmen that are ambivalent as to a major in computer science or physics. It is to these ends that the department has integrated courses from the department of Math/CS and Physics. Our primary concern is that this option will become so popular that our other programs could be affected

negatively. However, the prospect of a synergetic effort between two departments should overall strengthen the two departments both in a spirit of cooperation and class sizes.

3. Rationale and Discussion of Proposed Curriculum

The departments believes the proposed curriculum satisfies the following desired goals:

- To prepare students to understand the basic concepts and ideas of physics.
- To provide the student with abilities in the application of fundamental principles to solve problems in a theoretical and experimental environment. The level of such competence is to be such as to adequately serve the student in either industry or graduate work.
- To introduce engineering concepts, principles, and activities to those matriculating in Engineering Physics.

The department has identified a core of courses that it feels every student should encounter if they are to identify with the field of physics. The remaining course requirements depend upon the major and the degree required.

a. Core Curriculum

The core should provide to the student the fundamentals of physics along with sufficiency in mathematics. As one can see from the proposed curriculum in Appendix D, the fundamental areas of Mechanics, Electromagnetism, Quantum Mechanics, Introductory Relativity, Thermodynamics, and Laboratory Experiences, are presented to the

student at a sufficient degree of rigor. The Modern Physics course provides the student with relativity theory and elementary quantum theory as well as fundamental laboratory experiences whose difficulty lies beyond those labs associated with University Physics. The Engineering Physics major has an option of taking either the core course in mechanics (Analytical Mechanics) or the Engineering Mechanics course.

The mathematics portion of the core contains three semesters of calculus. The first two semesters are the standard year of calculus while the third semester is multivariate calculus. The final semester of required math is a new course being offered by the math department in service to the Physics/Engineering department majors. It is Applied Math and incorporates several distinct areas of math that are utilized heavily by the Physics/Engineering Physics majors (differential equations, partial differentials, Fourier analysis, and LaPlace transforms). Although not placed in the required category, each student will be urged to take Linear Algebra and Complex Variable.

b. Physics (AB)

This degree option provides the student the most flexibility. It is for the individual that considers his degree in Physics a terminal degree and will find his professional fulfillment in another discipline, such as business, law, or medicine. This degree would also prove flexible enough to allow individuals to prepare themselves for graduate work in cross-disciplinary fields such as biophysics and biomedical physics. It would seem imperative for an AB degree that they are

fairly well rounded in the sciences and hence a full year of chemistry is required. One further advanced physics course is suggested. This degree provides the student with 19 hours of electives. The department strongly suggests that a minimum of 4 of these 19 hours be elected in the computer sciences.

c. Physics (BS)

This degree is for that person who feels that he or she will want to continue their studies for an advanced degree in physics or the physical sciences. This individual will essentially be required to take most of the courses that are offered by the department except for those associated with engineering. This person should also have a full year of chemistry. An extensive amount of laboratory experience is allied with this degree. This degree allows the student to opt between Organic Chemistry and Digital electronics/Computer Interfacing. This option is a tough call. Both are valuable support courses for this degree. The Organic Chemistry may be a surprising option but the department feels it is a significant course in several ways. First, it presents physics students with a completely different method of scientific investigation and significantly broadens their scientific maturity. Second, no matter what scientific endeavor you go into, there seems to always be an organic molecule involved in some fashion. It is our hope that most students will choose to take both options.

One other feature of this major that the department feels is vital and that is a developing maturity in laboratory techniques and experiences. Hence, an Atomic, Molecular, &

Optical Physics Laboratory experience is required. This requirement will provide extensive use of quality equipment in a complex environment. This environment will focus on techniques and experiments in the field of atomic and molecular physics. It will also provide experiences in computer interfacing to instrumentation and the use of commercial laboratory software (TestPoint software produced by Capital Equipment Company in Massachusetts and distributed by Keithley Instruments).

A glaring omission in this curriculum is a programming requirement. It is hoped that the student will recognize this need when it is presented by his faculty advisor and will readily choose it as an elective. Other strongly suggested course electives are Linear Algebra (2 hrs) and Complex Variables (2 hrs).

d. Engineering Physics (BS)

This is a program that provides several options for a student upon graduation. It certainly provides a viable degree for an individual that desires to enter immediately upon graduation the work force in some technical area. It also provides a basis for entering graduate school in engineering. The department has had several of these majors enter engineering graduate programs in Mechanic Engineering and Electrical Engineering. To encourage our efforts and belief in the department's basic pedagogical approach and curriculum content we relate a portion of a letter received by the department from a recent Engineering Physics graduate who is presently a second year graduate student in mechanical engineering at the Univ. of Oregon.

In the letter he expressed his feelings as he encountered the graduate program, its courses, and fellow graduate students. He says,

> "...most important, I know that any student who successfully completes an Engineering Physics degree at PLNC is capable of pursuing any engineering discipline."
>
> ---Russell Smith ('97 Grad)

It should also be stated that a student who obtains a degree in Engineering Physics at PLNU who decides to obtain a graduate degree in Physics is prepared to do so.

Essentially this program differs from the pure Physics major by requiring a series of engineering courses offered by the department. A new course has been added in the field of Robotics. It is hoped that this course will begin to establish in the department a degree of engineering activity that has not been present.

Again, this program is void of any programming requirement. However, a programming class in C++ (4 hrs) will be strongly suggested as will Linear Algebra (2 hrs) and Complex Variables (2 hrs).

It must be mentioned that the Engineering courses through Engineering 215 can be obtained by the end of the second year and provide an acceptable 2-year preparation for pre-engineering students who desire to transfer to an ABET engineering program. The department has specifically geared these requirements to those

at California State Polytechnic University, Pomona.

e. Physics and Computing (BS)

As previously mentioned, this program could prove to be one of our most popular. Coupled to the core Physics requirements are 20 hours of Computer Science. These 20 hours include the initial 12 hours required of a computer science major. Scheduling and the interest of the student determine the remaining eight (8) hours. Only one (1) advanced course in physics beyond the core is required. Unfortunately, no chemistry is required of the student. How a student uses these electives is vague. They could profitably take math, physics, or computer science courses.

f. Introduction of a minor in Physics

There has been resurgence in the University of offering minors. There are several advantages to such an offering to both the department and the student. The major that would most likely pursue a minor in physics would be in math. Encouragement of obtaining a tangible 'product' such as a minor in physics would hopefully encourage math majors to expand their professional background in an area that would apply mathematical skills. It is with this intent that the department proposes the following minor:

Requirements for a Minor in Physics

- Physics 241, 242 (University Physics I & II)
- Physics 304 (Modern Physics)

- Eight (8) more hours of Physics or Engineering courses at level 300 or above.

4. Faculty and Student Load Analysis
   a. Course hours offered by the department

Course deletions:

i. Phys 380-Intermediate Lab.....1 hr
ii. Phys 480-Advanced Laboratory.....1 hr
iii. Phys 432-Quantum Mechanics II.....3 hr
iv. Phys 274-Modern Physics.....3
v. Engr 355-Analog Electronics.....3 hr
vi. Engr 425-Digital/Micro Electronics..4 hr

Total Hours Deleted.....15 hr

Course Additions:

i. Engr 354-Analog Electronics.....2 hr
ii. Engr 423-Digital Electronics.....2 hr
iii. Engr 424-Interfacing.....2 hr
iv. Phys 304-Modern Physics.....4
v. Phys 443-Solid State Physics.....3 hr
vi. Phys 481-Atomic, Molecular, & Optics Lab .....1 hr
vii. Engr 415-Robotics.....2 hr

Total Hours Added.....16 hr

Course No. Changes: Phys 172, 173 to Phys 241, 242.

b. Credit-Hour Comparison for Majors

Present Required Credit Hours Needed for:

AB (Engr. Phys).....61 hrs
AB (Physics).....55 hrs

Proposed Required Credit Hours Needed for:

AB(Physics).....54 hrs
BS (Physics).....66 hrs
BS (Egr Phys).....66 hrs
BS (Phys and Computing)...66 hrs

c. Effect on Faculty Loads

Since the total number of hours added to the curriculum was only 1 hour, the effect on faculty load is negligible. Upon analyzing each semester load it was determined that 72 hrs of faculty load will be available each year. This number will continue to require three full-time faculty.

B. Robotics Research

The department has recognized for some time that engineering experiences and opportunities have been lacking in the Engineering Physics major. The department has introduced experiences in CAD in Egr. 112 and machining via a special topics course, but more academic and rigorous experiences are needed. To remedy this deficiency, two things should be done.

- A faculty member with engineering experience should be in the department.
- Create course(s) and a research program that implement engineering principles.

The first item above is a remedy that will have to be considered in the future since the department is currently fully staffed. However, the second remedy can be addressed immediately. The proposed curriculum introduces a course in Robotics with an accompanying laboratory. Also, the department is initiating a research program in robotics. The course will act as a precursor to research activity by the

students, thereby enabling a 'jump start' on any research activity. It is vitally important, as anyone in undergraduate research has discovered, to have courses that directly support a research endeavor. The chemistry department at PLNU has long known this fact and has skillfully directed their students through a curriculum in organic chemistry that enables the student to do meaningful research by their senior year. The process of developing maturity in a topic is difficult at the undergraduate level because of the fragmentation of the undergraduate's life both personally and academically.

Robotics has been chosen by the department to be the focus of an engineering effort and in particular, autonomous mobile robotics. This field was chosen for several reasons.

1. Integration of several engineering fields as well as other scientific areas.

   With autonomous mobile robotics, there are three fundamental questions that the robot must consider:

   ✓ Where am I?
   ✓ Where am I going?
   ✓ Is there anything in my way?

   To design, construct, and program such a robot incorporates myriad aspects of mechanical, electrical, and computer engineering. One must also apply physics, mathematics, and computer science fundamentals in robotic development. In fact, one discovers in dealing with these three basic questions for mobile robots, principles in learning theory (psychology) and instinct theory (biology) must be examined. Perhaps no area of study incorporates a greater diversity of

disciplines than mobile robotics. Coping with such an integration of knowledge is one of the most basic tenets of a liberal arts institution.

2. Cost effectiveness

Research in any area tends to be expensive, particularly in the physical sciences and engineering. However, robotics is the exception. The miniaturization in size and cost of motors, electronics, microprocessors, micro-controllers, and computer memory has enabled robotic sophistication with little expense. Perhaps the provision of the necessary physical space is the largest cost of such an endeavor.

3. Exciting and Relevant Field of Study

One does not have to search too diligently to discover that the field of autonomous mobile robots is a highly pertinent area of investigation in the engineering and scientific community. Its applicability runs the gamut from defense systems to medical research to cleaning corridors. Students find the field very stimulating because of the tangibility of a robot and the resulting feedback it provides as it responds to an individual's effort in construction and programming.

4. Cooperative Effort with Computer Science

As one begins to develop an investigation into mobile robots, they become aware that robustness of the robot is one of the most sought after goals. Robustness meaning that the mobile

robot does not easily become 'lost' and if so the robot can rediscover its location and continue to perform its appointed task. It is essential that the robot always be able to answer the first fundamental question "Where am I?" If the answer to this question is in doubt all other activity becomes worthless. Also, one can only program so many subroutines into a robot to respond to various situations that it may encounter, and there will always be predicaments facing the robot that the developer never imagined occurring. Can the robot remain viable during these new and unforeseen situations? The degree to which a robot can survive confusion of location and unanticipated problems is a measure of its 'robustness'.

Essentially to gain robustness the robot must be able to 'learn' as it operates. It must have the ability to 'recognize' and 'react'. Such abilities imply that a neural network be established for the robot. Fortunately, in the Computer Science department a faculty member is involved in research involving neural networks and pattern recognition. This ability to possibly involve other faculty in this research gives a research program more stability and a greater chance for success.

The department recognizes that one does not do research in any field without first acquiring suitable knowledge and skills. To this end a Physics Department faculty member (Walker) spent his sabbatical in 1997 as a visiting fellow at the University of Manchester, Manchester, UK, studying and working in the area of mobile robots. During this time, a research problem was determined and this past year money was obtained to begin research on the selected problem. Also, a junior Engineering

Physics student has been appointed to work on the project for the next two years. It is the department's goal to have a fairly developed research program in mobile robotics in the next five years.

## C. FACULTY/STAFF

Presently, the department is fully staffed but it is prudent to contemplate faculty the department should be considering in the coming years. This report has emphasized the need for a faculty member that could teach, counsel, and direct students more professionally in engineering fields. A person who would best fill this need would be an individual with an advanced degree and experience in Electrical Engineering or Engineering Physics. Such an individual could service adequately a number of the department's present courses such as Electromagnetic theory, Analog and Digital Electronics, Interfacing, and, of course, the general level physics and engineering courses.

It is quite possible, depending on the type of emphasis received during their graduate work and subsequent career, that an individual in Computer Engineering would fulfill the requirements. Such a person and their training would need to be scrutinized carefully.

Another position that is vitally important if a viable spirit of engineering is to be achieved is in the staffing of the machine shop for maintenance and instruction. It is believed that such an individual can well pay for themselves as support services for all the sciences. Presently, Dr. David Brown in biology is handling this position. It is a service that is perhaps not well understood by administration and/or

faculty. Dr. Brown is doing a substantial amount of this work ad hoc, in fact, it is mostly a labor of love and is much appreciated by the Physics/Engineering department as he has serviced a number of our students in learning how to machine. He has also provided much needed services to other departments that required his expertise and the machine shop facilities. It is hoped this important support service could be given stable footing with adequate staffing and integrated more fully into the science program. It is no exaggeration that the presence of a machine shop is often a litmus test for the categorization of a science program as one of quality.

## D. STUDENT ATTACHMENT

How a department goes about the process of 'attaching' students to the department's facilities, equipment, and program is nebulous. This indeterminacy has essentially led to inaction by the department. But such a goal is highly desirable and is an attribute of an academic program of high caliber. Unfortunately, there are forces present to prevent the obtainment of such an objective. The fragmentation of schedule and life style of students works against their involvement in any effort that requires a structured time commitment. Their lives are more analogous to 'broken field running' rather than a scheduled and well-formulated 'play'. However, it would appear that several things are necessary in establishing the quality of student attachment.

- A 'place' in the department that the students involved in lab assisting, grading, and general work could call their own. A departmental assistant's office space is of absolute importance in establishing attachment of the student in the

affairs and well being of the department. Any future building or remodeling of the Physics department should incorporate an area for the departmental assistants. This space should be 150 - 200 $ft^2$ and situated centrally in the department.

- Faculty commitments in providing meaningful work opportunities and then furnish direction to those students. Such an involvement is a time consuming effort for a faculty already heavily involved in departmental and university responsibilities. How the department faculty balances these efforts is a major problem and a solution is not forthcoming other than 'just doing it'.

E. Facilities

The department is hopeful that basic changes could be made in the facilities of the department.

Minimal changes:

- New flooring, cabinetry, painting, and bench tops for the two-lecture/lab rooms.

- Obtainment of 200 $ft^2$ of securable space for the expressed purpose of housing research efforts in robotics as well as providing space for the laboratory associated with the newly created robotics course. Such a space would also provide a 'location' for the student selected as the research assistant in robotics.

Further Needs:

- Separation of the lecture function from the lecture/lab rooms. These rooms should eventually be utilized entirely for laboratory purposes.

- Expansion of the machine shop area to about 600-800 $ft^2$. Present conditions are very cramped and result in an unsafe environment as well as not being conducive to the full utilization of the equipment.

- Creation of a departmental assistants' office area. This room should incorporate ideally 200 $ft^2$ of floor space.

- Creation of a storage facility for the department. This storage area should be convenient with regards to access by the department and securable. The size should be around 300 $ft^2$.

F. Time Line

This review has presented changes and goals the department considers important. A proposed time line for their achievement is supplied below.

1. Immediate Goals (1 year)
   a. Modified curriculum.
   b. Introduction of BS degree to accompany the AB degree.
   c. Introduction of a minor in Physics.
   d. New Program (Physics and Computing).
   e. New research emphasis (Robotics).
   f. Promotion of external summer experiences for Juniors and Seniors.

2. Intermediate Goals (2-5 years)
   a. Remodeling of laboratories

b. Increasing the number of computer stations in the Introductory Physics Laboratories from 4 to 8.
c. Develop and begin to implement a procedure to more actively involve majors in departmental day-to-day operations.
d. Obtainment of physical space for a Robotics Laboratory.
e. Provide adequately prepared staffing for the Engineering 111, 112 sequence.

3. Long Range Goals (5-10 years)
   a. Obtain a faculty member with engineering experiences and/or engineering degree.
   b. Machine Shop expansion with part-time staffing.
   c. New science facility.

## III. SUMMARY

The Physics/Engineering Department at PLNU is presently doing a good job in preparing students for their professional goals as evidenced by the returned surveys and the performance of its graduates. It is believed that the department can, however, become even better. The curriculum has been adjusted to compliment more fully the talents of the faculty as well as to enhance the development of the majors in the department. Bachelor of Science degrees and a new program, Physics and Computing, have been proposed which the department believes will service students more adequately upon graduation. A new research area has been introduced and implemented to promote experiences appropriate to the Engineering Physics major. These proposed changes will cause little expenditure and upheaval of the department and its students.

The department recognizes its past failure to promote external experiences to students but has demonstrated its progress in providing encouragement and expectation to students in this channel of education.

This review has also articulated weaknesses whose elimination will need to be addressed in the future. Remodeling of the physics labs is definitely required in the near future. The need to have on the faculty of the department an individual with engineering training and expertise was argued. The desire to incorporate the physics and engineering physics majors into a more active role of participation in the department was articulated.

And finally, the department has voiced its acknowledgement of the constant struggle to maintain a curriculum within the philosophical mission of a liberal arts education that will provide the students not only the fundamentals of physics but also the technical skills so vital in today's marketplace.