# New Mexico State University
# Engineering Physics External Advisory Board
# 2014 Report

## Executive Summary

The Engineering Physics (EP) degree program, about to begin its fourteenth year, has developed into a successful, accredited, and growing component of the physics and engineering departments at New Mexico State University. The Engineering Physics Program is challenging, and as a result, attracts some of the best and brightest students at the University. Along with high caliber students, the Physics Department faculty members are a major strength of the program, exhibiting a dedication to both program excellence and student achievement. Program objectives, in terms of graduate competitiveness, adaptability, and teamwork and leadership skill, continue to address the curricular interests of the students, while reflecting the needs and desires of the constituencies being served by the program. Graduates of the program have demonstrated success at finding employment within industry and laboratory settings, or moving on to advanced study in physics or engineering. Highlights of the program's successes are included in below.

The Engineering Physics Program; however, like many non-traditional, joint-department degree programs throughout academia, continues to encounter challenges. Challenges related to support received from the partnering colleges and departments, overall program resources, program coordination, curriculum conflicts, and student opportunities outside of the classroom, have made the accomplishments of the faculty responsible for building this program that much more impressive. With this report, it is the intent of the Engineering Physics External Advisory Board (EPEAB) to congratulate the faculty of the Physics Department for successes achieved to date, to point to potential new opportunities that might be realized, as well as to highlight the most important issues that, if ignored, could threaten the health of the program. We offer this information with the best interests of the students, the EP Program, and the University in mind.

Resources, support, and program coordination continue to be issues for the Engineering Physics Program. However, since the EPEAB's last report, program faculty and administrators have developed, and are maintaining, stronger lines of communication with department heads, deans, and the highest levels of University leadership. One aspect of better communication that could still be improved is an integration of the Engineering Physics Program strategic plan with Partnering College and University strategic plans, to better facilitate program support and execution. Likewise, a program designed to serve students and faculty across two colleges and five departments requires stronger coordination and shared support between the partners to remain a strong, growing, and vibrant program, and to give the program its deserved recognition and identity among the student population. More recent issues related to current program size and potential continued program growth present new, but more modest, challenges than in previous years. These issues have been highlighted, and are discussed, below.

The report concludes with a discussion of potential opportunities and threats, for the program administrator's consideration, as well as some comments regarding program objectives, implementation of additional computational methods instruction, and proposals for a new photonics concentration.

## 2014 EP External Advisory Board Meeting, Charter, and Membership

The Engineering Physics External Advisory Board (EPEAB) convened for its eighth meeting on Thursday and Friday, April 24th and 25th, 2014. The meeting was hosted by the Physics Department and held in Gardiner Hall on the main campus of New Mexico State University (NMSU) in Las Cruces, New Mexico.

The current charter of the EPEAB is to:

1.) Review the current policies and procedures within the program and within the university administration in order to identify strengths and weaknesses;
2.) Identify issues within the program, the department, and the university that directly affect the EP program and make recommendations for improvement;
3.) Identify potential opportunities and threats to the future of the EP program;
4.) Evaluate whether the EP Program achieves its stated Program Educational Objectives;
5.) Provide feedback on a plan to implement computational methods into the EP curriculum;
6.) Consider the benefits and drawbacks of a proposed photonics concentration; and
7.) Prepare a report to be presented to the Engineering Physics Program Committee for distribution to the deans.

The current EPEAB represents the various constituencies served by the Engineering Physics (EP) Program, with representatives from academia, federal science laboratories, industry, and program alumni. Additionally, the EPEAB has both in-state, and out-of-state representation, with both continuous long-term and new membership.

## Program Strengths and Weaknesses

*Strengths*

ABET re-accreditation granted in 2013: The Engineering Physics degree program, which was first proposed in 2001, is now a successful, accredited, and growing component of the physics and engineering departments at NMSU. ABET accreditation was awarded in 2007, and the program received re-accreditation in 2013. Engineering concentrations include Electrical, Mechanical, Chemical, and Aerospace Engineering.

Faculty commitment to EP Program: The EP Program enjoys the full support of the College of Arts and Sciences and the Physics Department, while the associated faculty demonstrate a dedication to the students and to the continued success of the program. The Physics Department faculty members are a major strength of the program. Faculty members in the NMSU Physics Department are skilled and dedicated educators engaged in a diversity of research activities, including: nuclear physics, condensed matter physics, geophysics, atmospheric physics, optics, and physics education. Additionally, faculty members are engaged in both theoretical and experimental research and technical activities. This diversity of research offers students a broad spectrum of opportunities at

the undergraduate and graduate levels, a richer educational experience, as well as healthier employment opportunities upon completion of their degree requirements.

Opportunities for undergraduate research: Past EPEAB reports have noted a need to provide on-campus undergraduate research opportunities for the EP students. Over the years, the department and the program have seen the advantages in doing so, and are now presenting students with opportunities to conduct research in optics and materials science, particle and nuclear physics, geophysics, atmospheric physics, cosmic ray and space physics, and physics education.

Enrollment, graduation, and retention rates: The EP Program saw its first graduate in 2004 and has seen 24 graduates to date. Enrollment continues to increase, and in the Spring 2014 semester, EP enrollment equaled the enrolment in the more traditional physics program. From a low of less than 20 undergraduate students in the mid 90s, the physics department has grown to approximately 100 students, thanks in large part to the EP Program. Graduation rates also are increasing, with 9 graduates expected in 2014. Furthermore, a 2012 survey revealed the EP Program has much better than average retention rates: close to 50% of incoming freshman remain and graduate in EP, outperforming other departments at NMSU.

Graduate jobs/salaries: Typically, program graduates move on to advanced study in either physics or engineering graduate programs, or to careers in industry. Employment rates are high and salaries appear to be very competitive. Details of relevant statistics are presented below.

*Weaknesses*

Need for computational methods: The Physics Department and the EP Program have done an excellent job in addressing previous EPEAB concerns and issues, and at this point it has become difficult to note any significant weaknesses of the program. Indeed, the EP Program appears to be one of the strongest programs on the NMSU campus, for reasons mentioned herein. We do note a perceived need for adding more computational methods instruction within the program as presented. However, we also note that a plan for just such additions to the curriculum also was presented during the review meeting, and we point readers to the section below on that implementation plan.

## Issues and Recommendations for Improvement

The Engineering Physics Program has grown into a successful component of the Physics Department and it has become apparent that their many successes greatly outweigh any deficiencies. The EPEAB believes the EP Program is the star program at NMSU due to many factors including: program growth, committed faculty, excellent students, the obvious close relationships between students and faculty, and a national need for the skill sets being taught. The EPEAB offers congratulations to the physics department faculty that have created this opportunity for the university.

The challenge, at this point, is to take something that is healthy and successful, and seek continued enhancement. With this goal in mind, the EPEAB offers up the following insights into continuing issues and our recommendations for their improvement.

*Partnering College and Department Support*

Issue: The Engineering Physics Program is designed to uniquely combine critical educational assets offered by the Physics Department within the College of Arts and Sciences and those offered by the partnering engineering departments within the College of Engineering. Through the diverse inter-college curriculum, the program provides combined benefits to the students, and provides opportunities for the associated faculty and the participating departments, as well. Departments benefit through revenue sharing, and faculty benefit from a higher caliber student population, from which to draw graduate student candidates, thus assisting with research programs.

Despite this joint venture, and increasing program success, the EP program continues to suffer from a lack of identity and recognition. The program is administered by the Physics Department, yet students graduate from the College of Engineering. And while the program is administered exceptionally well, there is an apparent inequality in support offered back to the program between the College of Arts and Sciences and the College of Engineering, as well as an apparent inequality in program coordination, execution, participation, and ownership between the Physics Department faculty and the partnering engineering department faculties. While there is enthusiasm for the EP Program, the primary burden of program administration and support appears to have fallen to the Physics Department. The lack of institutional support for program administration combined with the growth of the program puts the EP Program at risk.

Recommendation: Communication of this report to appropriate University administrators, deans, and department heads is highly recommended and should serve as a starting point for better coordination of the EP Program between the associated colleges and departments. Engineering deans and department heads are encouraged to look at the EP Program as an asset to the College of Engineering and ask for increased faculty, administrative, and coordination support. The EPEAB further recommends considering the establishment of an oversight committee, with joint participation from the Physics Department and the partnering engineering departments, and regularly scheduled review meetings to bridge the college and departmental gaps in program support and participation, and to increase streamlined efforts to enhance the program in the interests of the students and faculty. The establishment of such a committee should go hand-in-hand with substantial College of Engineering participation in the next EPEAB meeting.

*Resources to manage program*

Issue: Management and administration of the EP Program is the sole burden of the Physics Department and generally comes from resources prescribed to that department from the College of Arts and Sciences. However, the College of Engineering does benefit from this program through quality students, increased credit hours for engineering

courses, and higher graduation rates from their departments. Management and administrative resources, shared between the colleges, would be a huge benefit to this program.

Recommendation: From a financial perspective, the lack of support at the college level is believed to be due, in part, to the University lacking a strategic plan for sustainable growth of its technical programs. As NMSU adopts a strategy for education, the EPEAB recommends seeking input from external constituents. We further recommend that the University push budget, staffing, and teaching load authority to the lowest practical level consistent with budgetary constraints. However, the board recognizes that many support staff needs of the EP Program could benefit through shared resources with the partnering engineering departments.

One obvious example where shared resources would benefit the EP Program is the Capstone projects. The process of conceiving the ideas for a Capstone project, approving a project, monitoring project progress, etc, is currently very ad-hoc. In the past, advising for Capstone projects often has fallen on the Physics Department faculty, but project coordination has been difficult between the physics and engineering departments. Occasionally, students get conflicting advice from the engineering faculty. Since these projects are already a part of the engineering curriculum, involvement of Physics faculty should be expected to require only a reasonable time investment on the part of the faculty members involved, and certainly, few Physics Department faculty have time to serve as official Capstone project advisors. The EPEAB recommends that EP Program students pursue their Capstone projects within their Engineering concentrations, thus alleviating one of the current burdens on the Physics Department faculty.

*Program coordinator*

Issue: Another possible shared resource that would require minimal support, but that would reap potentially huge benefits is a program coordinator. This position could alleviate many of the responsibilities currently placed on the Physics Department and could help in program coordination between colleges.

Recommendation: The EPEAB recommends discussion beginning at the Dean level on the possibilities of the College of Engineering supporting a program coordinator for a program that delivers high caliber students to, and graduates of, their departments.

*Graduation rates/curriculum conflicts*

Issue: While EP Program graduation rates are high, the curriculum remains one of the most difficult to complete, and one of the most difficult to navigate, on campus.

Recommendation: It appears that experience has allowed EP Program faculty to streamline the curriculum, but stresses remain to update courses, design and include new courses, include new course content, etc. The EPEAB recommends continued attention on this issue in the interest of providing students a reasonable chance to complete the

requirements for their degree in four to five years. Where appropriate, opportunities for advanced coursework should be considered within the context of four-plus-one Masters degree programs to alleviate the issue.

Furthermore, the EPAB recommends that the Physics Department work with the partnering engineering departments to identify disciplines, for which a Bachelors degree in Engineering Physics could be combined with a Masters degree in Engineering. In other institutions, these programs provide a reliable source of high-caliber graduate students to the engineering programs, while providing expanded opportunities for EP students. Such programs could help alleviate recruitment and retention issues, while reducing tension between the EP and engineering programs in undergraduate recruiting.

*Internship opportunities*

Issue: While EP Program graduation rates are high, and graduates are successful at finding employment, the EPEAB believes the program is not taking full advantage of opportunities for summer internships within the local New Mexico industrial and governmental sectors.

Recommendation: While the EP Program appears to enjoy healthy connections to academia and industry, as demonstrated by the documented success of students moving on to graduate programs and careers in high-tech manufacturing and industrial R&D, the program's connections to federal science labs and industry within New Mexico could be strengthened significantly. Student employment opportunities abound at Los Alamos National Laboratory, Sandia National Laboratories, and Intel Corporation, and the faculty may even benefit through the connections their students make. Recent improvements in connections to the Department of Defense, NASA, and a broader spectrum of industry should continue to improve prospects. These contacts should not be left solely to the departments and programs, but should become part of NMSU's administrative strategy.

*Program recognition and employment opportunities*

Issue: Job marketability of EP graduates is a concern, in that graduates are qualified for both physics and engineering fields, but do not strictly specialize in either.

Recommendation: The EPEAB recommends development of a placement program and closer partnership with the career development center on designing resumes specific to the EP degree. If possible, a Program Coordinator could work with career advisors to reach out to potential employers to educate them on the EP degree and its unique advantages, as well as to obtain their feedback on their employment needs.

There may be a need to determine the types of disciplines and industries that are and should be, targeted for the EP degree. With this information, a network of employers could be developed for the graduating EP students.

There may be a window of opportunity for marketing the EP Program to potential employers. Estimates are that only 20% of universities offer this degree. Promoting the program now could put the University in a leadership role for this expertise.

## Opportunities and Threats

*Opportunities*

As mentioned above, the EP Program's connections to federal science labs and industry within New Mexico could be strengthened significantly. Student employment opportunities abound at Los Alamos National Laboratory, Sandia National Laboratories, and Intel Corporation, and the faculty may even benefit through the connections their students make. The pursuit of opportunities for students may very well lead to long-term relationships for faculty members, with potential partnering on research proposals and activities. These contacts should not be left solely to the departments and programs, but should become part of NMSU's administrative strategy.

*Threats*

The EP Program is quite small relative to their engineering department colleagues. Many of the resource issues that have arisen in this program are overshadowed by the very real problems faced by the much bigger engineering departments. But the fact remains that the engineering departments benefit by the existence of this very successful program, and modest assistance could bring about even higher levels of success.

Despite being a small program, the EP Program has grown considerably over the years, and likely will continue to do so. However, existing limited resources could turn continued growth into a serious threat as there exist serious resource needs at the current program size for dedicated staff mentors, program coordination with the engineering college, and related pressures.

## Program Educational Objectives

*EP Objective 1*: Competitiveness. Graduates are competitive in internationally recognized academic, government, and industrial environments

The EP Program is attracting top-rank students, guiding them through a challenging curriculum, with graduates of the program proving competitive in graduate-level academic, government, and industrial environments. EP Program graduation rates are increasing, and a 2012 survey revealed the EP Program has much better than average retention rates: close to 50% of incoming freshman remain and graduate in EP, outperforming other departments at NMSU.

As designed, career choices for graduating EP students are more diverse than physics department graduates. Typically, program graduates move on to advanced study in either physics or engineering graduate programs, or to careers in industry. Job placement and

graduate school admission rates are above 90%. Senior exit interviews indicate student satisfaction with the program and provide the following statisitics: 67% of graduates employed immediately upon graduation (84% within 3 months, and 100% within 6 months), with $70k average salary, and 92% currently employed in a science or engineering field.

*EP Objective 2*: Adaptability. Graduates exhibit success in solving complex technical problems in a broad range of disciplines subject to quality engineering processes.

EP Program graduates appear to exhibit broad success across a range of disciplines. Of those graduates employed in industry, only 15% have changed employment. This is quite exceptional, considering the state of the U.S. economy over the past 6 years. Of these same graduates, 30% have indicated a promotion to higher-level jobs with the same employer. And again, the diversity of career choices is much broader than for typical physics department graduates.

*EP Objective 3*: Teamwork and Leadership. Graduates have a proven ability to function as part of and/or lead interdisciplinary teams.

EP Program graduates have been trained well to work as part of, and to lead, interdisciplinary teams. 23% of program graduates list surpervisory duties and 92% report working in team environments.

**Implementing Computational Methods into the EP Curriculum**

EP students currently take various computational courses in their engineering departments. These courses are primarily MatLab based. The Experimental Modern Physics (PHYS 315L) course requires some real data analysis, for which many students have taken to MatLab as the tool of choice. Computational Physics (PHYS 476) teaches more advanced numerical techniques, and Modern Materials (PHYS 489) involves the solution of several computational problems; however, these courses are electives.

The EP Program is investigating the potential benefits of using MatLab throughout the EP curricula. Both Colleges of Arts and Sciences and Engineering have MatLab licenses, providing access to this program for students in any course or lab. The plan is to provide a standard computational tool for students, and one which they will be trained to use before the start of their Capstone projects.

The College of Engineering is introducing a three-credit course (ENGR 100) required for all entering students. Some Engineering departments will drop their computational course to make room for these three credits. All departments with an Engineering degree, including the EP Program, are asked to teach one section of ENGR 100. The content of this course is a subject of much discussion, with topics including: interdisciplinary teams, mission-oriented problem solving, mathematical modeling of engineering problems, and the use of computation to optimize parameters of a mathematical model.

The EP Program's plan forward involves introducing a PHYS 100 course, cross-listed with ENGR 100. This course would contain a variety of physics and engineering students. The plan would be to teach the same "problem-solving" approach as in other sections of ENGR 100, using MatLab as the computational platform. MatLab also would become the principal computing platform for PHYS 315L, PHYS 476, and the advanced lab courses. Instructors of all Physics courses would be encouraged to introduce computing projects using MatLab.

The EPEAB believes this implementation plan is an excellent start to addressing the need for increased computational methods instruction. The proposal builds off of the existing use of MatLab for some of the EP students engineering courses, and the existing MatLab licenses make the plan very feasible. Indeed, MatLab is the optimal choice, in particular, because of the wide-scale adoption by engineering departments, both internal and external to NMSU. The standardization of MatLab, while somewhat constraining, will provide students with opportunities to learn from, and help, each other. Of course, as with any commercially available computational tool, there is a danger of MatLab becoming a "black box" for students, so the focus should be on the development of critical thinking skills and the use of MatLab as a tool to better understand physics problems and their potential solution.

**Benefits and Drawbacks of a Proposed Photonics Concentration**

The EP Program proposes to introduce a new concentration in Photonics to augment the current concentrations in Mechanical, Electrical, Chemical, and Aerospace Engineering. This new concentration would be similar to the Electrical Engineering concentration, but with a focus on Photonics. Offering this concentration would require the inclusion of three existing optics courses, with labs, into the EP-EE curriculum.

The stated purpose of this proposed new concentration is to increase enrollments in optics courses both in physics and EECE, to prepare undergraduate students for graduate study in optics, and to prepare undergraduate students for careers in optics, and especially important topic to New Mexico's local Intel Corporation.

The EP Program has focused program structure on combined physics and engineering disciplines. When considering new specializations, the program has looked to partnering engineering departments. This proposal goes one level deeper and focuses on a sub-discipline as a potential concentration.

The EPEAB feels that this proposal is too specialized and would overly constrain both the department and any prospective students. For example, an EP student with a Photonics concentration likely would see far fewer career choices upon graduation than an EP student with the more general EE concentration. On the more pragmatic side of things, this proposal also requires extra credit hours for completion, which would put a strain on students already attempting to coordinate one of the more difficult curriculums on campus. We advise consideration of a four-plus-one Master's program to increase enrollments in the associated courses and to prepare students for careers in optics.