PHYSICS FIVE-YEAR PLAN (2011-2016)

1. INTRODUCTION

Since our last external review in 2006, the Department of Physics has grown and changed dramatically. In that time, our faculty has developed several independent projects in science outreach and informal learning, including traveling museum exhibits (Martin Kamela), after-school robotics (Kyle Altmann), science and spirituality books (Pranab Das), and science in virtual worlds (Tony Crider). We have hired a lecturer that publishes astronomy poetry (Claudine Moreau) and a second astrophysicist that regularly appears on national television (Dan Evans).

We have also tripled the number of majors. Before 2007, we were graduating two-to-three physics majors per year. In 2010, we graduated nine: 6 physics majors and 3 engineering physics majors! The quality of of our majors has increased, with freshman assessments revealing that our incoming students know more physics each year.

In response to these changes, we have deepened and expanded the first two years of our physics sequence. These now include the computationally intensive Matter & Interactions pedagogy during the freshman year and Modern Astrophysics as a bridge between freshman year and Modern Physics. We have also revised our requirements to be more rigorous (for the BS) and more flexible (for the AB). Finally, we have very recently added a Minor in Astronomy for both physics major and non-majors with an interest in that topic.

To better facilitate engaged learning in new curriculum, we have remodeled our classrooms into lab spaces that mirror and improve upon the SCALE-UP physics classrooms at North Carolina State University. We have also invested heavily in a new nanotechnology lab for our 2008 hire, Ben Evans, leading to award-winning research by several of his students.

These accomplishments and others have led to our department being recognized as a regional leader in physics education. This fact is most evident at meetings of the North Carolina Section of the American Association of Physics Teachers and Zone 5 of the Society of Physics students, where our faculty and students are frequently officers, award winners, or conference hosts.

2. MISSION STATEMENT

The Department of Physics at Elon University trains all of its students in a breadth of mind predicated on the ability to thoughtfully approach a wide range of problems. Major students are given an essential background in physics, research experience and, most importantly, problem-solving skills that extend well beyond the confines of any particular discipline. Non-majors are given critical thinking and problem solving skills and a knowledge base that expands their horizons and makes them better citizens of an increasingly technological and scientifically oriented society. We offer students a chance to become powerful thinkers with wide-ranging intellectual curiosity and the capacity to engage in problem solving at all levels. Our faculty is fundamentally committed to both disciplinary and interdisciplinary scholarship and serves as a model of broad intellectual engagement. Our students and faculty are leaders in the intellectual life of the College and our graduates have the capacity to excel in any field by dint of their refined problem solving skills and capacity for intellectual engagement.

3. PROGRAM GOALS

FOCUS 1: GLOBAL CITIZENSHIP

The Elon Commitment: Be a national leader in preparing students to succeed in a multicultural world.

Our Goal: Become a national model for science communication with the public.

To prepare our students to be global citizens, we will begin at home by engaging them with the residents of Alamance County. We also will establish both statewide and national media presences to provide opportunities for faculty and students to bring science to the community. We envision our new astronomy minor as a source of students to participate in such outreach. We are also considering expanding Martin Kamela's international traveling museum (currently used in India) to another country.

The majority of our current faculty have projects that focus on informal science learning, including traveling museum exhibits (Kamela), after-school robotics (Altmann), science and spirituality books (Das), astronomy poetry (Moreau), and science in virtual worlds (Crider). We would like to take these several separate initiatives and explore how they could be a focus for our department. The National Academies noted this a a burgeoning field in their 2009 publication, *Learning Science in Informal Environments: People, Places, and Pursuits.*

Another factor in this discussion is the new science building. We have been pondering what we might have in it that would strengthen a science communication focus. The answer that we came up with was a science destination such as planetarium, science theater, or science playground. This would be a valuable resources for residents of Alamance County and the Piedmont. Ideally, it would engage both science and communications majors in the creation of public science shows. In fact, we are considering creating science classes specifically for Communications majors to learn the science content and apply that knowledge to writing and producing planetarium or science shows.

2011-2012	● Identify model programs with informal science learning initiatives. ● Begin site visits to regional planetariums. ● Offer Robotics course that partners with Alamance County high-school FTC teams ● Hold scrimmage match for FIRST LEGO robotics teams. ● Host science poetry reading for Elon University community.
2012-2013	● Research literature on informal science learning at other institutions. ● Begin visits to national science theaters. ● Seek external funding to support middle-school FIRST LEGO robotics teams. ● Host regional science poetry reading.
2013-2014	● Develop Elon Science Theater donor brochure with Institutional Advancement. ● Seek external funding to support up to four high-school FTC robotics teams. ● Host regional FIRST or FTC robotics competition.
2014-2015	● Begin campaign to raise money for Elon Science Theater. ● Support Alamance County FIRST or FTC team to compete in national competition. ● Plan for national science poetry workshop.
2015-2016	● Begin search for Elon Science Theater faculty director. ● Support Alamance County FIRST or FTC team to place at national competition. ● Host national science poetry workshop.

FOCUS 2: STUDENTS

The Elon Commitment: Build a strong transitions program to careers and graduate school.

Our Goal: Create campus model for student career and leadership development within a major.

We will create a national model for four-year career building for physics majors, making them leaders among their peers in graduate school, teaching, and industry. This would weave together several existing class components into a more formal "199/299/399/499" structure. Courses in this parallel career track might include:

- ELN 101: STEM-themed Section (1 sh)
- EGR 103: Workshop Safety Certification (1 sh)
- PHY 199: Introduction to Research (1 sh)
- PHY 279: Teaching and Learning Science (1 sh)
- PHY 397: Research Methods I (1 sh)
- PHY 398: Research Methods II (1 sh)
- PHY 481: Summer Internship
- PHY 499: Campus Research

As part of our mission as a Physics Teacher Education Coalition partner, we are working with the School of Education to build a transition pathway in the sophomore year that could lead to careers in secondary education. This will build upon our ever-growing astronomy and physics TA program. To enhance the career awareness during junior year, we will invite representatives from Career Services to PHY 297/298 to discuss traditional and non-traditional career opportunities. We will also network with young alumni and graduate students and nearby colleges to offer career building advice. Finally, we will require all students who do external internships at national labs or REU programs to present their research on-campus either at SURE or within the department to expose all students to the types of opportunities available to them.

2011-2012	● Establish permanent ELN 101 section that is tied with STEM learning community. ● Write draft syllabus for PHY 199. ● Offer 1-hr course in SCI 279 for science department teaching assistants. ● Reapply for funding from PhyTEC. ● Begin (or reapply to) Noyce Scholars program with School of Education. ● Invite Career Services to visit PHY 397/398. ● Begin search for local companies that could offer summer internships to students. ● Establish recurring student/alumni mixers.
2012-2013	● Revisit EGR 103 structure. Consider splitting this into EGR 103/104 with some component that would be open to non-EGR majors. ● Submit SCI 299 course to UCC. ● Pilot PHY 199 course.
2013-2014	● Run second test of PHY 199. ● Explore mechanisms to double the number of student research opportunities per major project (e.g. faculty-team research, research classes).
2014-2015	● Submit PHY 199 proposal to UCC.
2015-2016	● Assess impact of 199/299/399/499 plan on enrollment, research participation, and placements after graduation.

FOCUS 3: FACILITIES

The Elon Commitment: Expanded academic facilities for science, communications.

Our Goal: Create new labs and rooms for engaging our students in science with the community.

To support the Program Goals of Global Citizenship and Faculty development requires improvement of and re-imagining of the facilities at the department's disposal. Our recent emphasis in astrophysics and astronomy, as evidenced by our most recent hire and new Astronomy minor, will also benefit from designated space. We make our plan with the expectation that within the next seven to ten years our physical space might increase with the construction of a new science building and/or reallocation of the current building's space. Until then, our proposed robotics outreach efforts will require immediate temporary space starting in 2012-2013. With the increasing amount of on-campus lighting near our astronomy lab observing platform (e.g. baseball lights, intramural fields, etc.), we need to move this to a new location. Finally, the ever-increasing number of students in biology, biochemistry, and exercise science and the new PA program will require us to equip a new General Physics lab room. We currently hope to transplant MCMI 207 classes (astronomy, geology, energy and the environment) to the basement and convert MCMI 207 into a clone of MCMI 203.

2011-2012	● Temporarily convert Kyle Altmann's lab into Robotics Lab. ● Revert MCMI 014 to Student Astronomy Lab. ● Hire new engineering director. ● Hire a one-year "Teacher-In-Residence" to teach General Physics and mentor Elon teacher candidates. ● Identify new potential sites for Astronomy Lab platform.
2012-2013	● Transplant engineering (3 offices+computer lab) and to MCMI ground floor. ● Create model computer/SCALE-UP classroom in MCMI ground floor. ● Move robotics lab to larger location in basement of MCMI. ● Purchase new platform/shed/trailer for astronomy lab program. ● Purchase equipment to convert MCMI 207 into a clone of MCMI 203 for additional sections of health-focused PHY 201: General Physics I and PHY 202: General Physics II.
2013-2014	● Develop Elon Science Theater donor brochure with Institutional Advancement. ● Begin holding astronomy labs at new location. ● Move MCMI 207 classes to basement.
2014-2015	● Begin campaign to raise money for Elon Science Theater.
2015-2016	● Prepare to move into MCMI II or prepare for others to do so. ● Model faculty office/student engagement areas after MCMI 202. ● Develop full plans for Elon Science Theater.

FOCUS 4: CURRICULUM

The Elon Commitment: Create innovative 4 + 1, 4 + 2 combination degree programs.

Our Goal: Establish new curricular tracks that lead to a BA+MAT in education and a BS+MS in engineering.

Our department will be exploring different combination degrees, including a BA+MAT with education and an additional dual-degree engineering option. The former will involve using the Physics Teacher Education Coalition model and supporting the School of Education in creating an MAT. (This is in addition to our plan for recruiting more students into our traditional 4-year physics teacher programs using Noyce Scholarships and PhyTEC best practices.) The latter will involve research of other dual-degree programs and renegotiating our partnerships with some engineering schools. We will also consider a full four-year rigorous BS in Engineering Physics that might better prepare students for graduate work in Engineering. This would likely include additional math and computer science classes. We also intend to offer 2-sh elective courses that would help engineers and physics majors explore a larger variety of topics.

2011-2012	● Research other dual-degree engineering schools. ● Hire new engineering director. ● Hire a one-year "Teacher-In-Residence" to teach General Physics and mentor Elon teacher candidates. ● Offer a 1-hr course, SCI 279: Science Education. ● Complete MAT plan with School of Education.
2012-2013	● Discuss 4+1, 4+2, and 3+2+1 engineering possibilities. ● Select one new engineering option for implementation. ● Recruit for first year of MAT program.
2013-2014	● Begin recruiting with additional engineering option. ● Begin first year of MAT program.
2014-2015	● Graduate first year of MAT program. ● Recruit second year of MAT program.
2015-2016	● Examine impact of MAT program and new engineering option on enrollment.

FOCUS 5: FACULTY

The Elon Commitment: Accentuate and support Elon's teacher-scholar model.

Our Goal: Establish national recognition for Elon's physics, pedagogy, and interdisciplinary research on par with our current statewide recognition.

Our faculty are already heavily involved in regional professional associations such at the NCS-AAPT and the North Carolina Astronomers. In the next five years, we will expand to a more national presence by attending and presenting at more national conferences. Departmental faculty are already recognized in a number of areas and the department will encourage them to continue their national and international activities that bring recognition to the department and Elon.

The Physics department will make a concerted effort to support its faculty and recognize their participation in this goal by:

- encouraging attendance at **one national or international** meeting, conference or workshop each year.
- encouraging attendance at **one pedagogical or education** meeting, conference or workshop (local, regional, national or international) each year.

Faculty will continue to mentor undergraduate research students and provide them opportunities to perform top-notch research on campus, and ultimately present research at the national levels. All ranks of faculty will publish in appropriate journals and magazines, in books and collections, or through other venues, the results of their scholarship. Some faculty members will promote via workshops Elon's unique active and engaged physics and astronomy pedagogy. We also plan for some faculty to take on service roles in national and international professional associations. Some of these service roles will provide our faculty exposure to innovative teaching techniques and the national dialogue on science education.

To increase resources available for new research, our faculty will explore new avenues for grants. Physics faculty will both work one another and in CATL and other grant-writing workshops to improve in this area.

2011-2012	● recommend that each faculty attend one national or international conference ● recommend that each faculty attend one science education conference
2012-2013	● identify appropriate national conference for regular student research presentations (e.g. SPS, AAS, APS) in addition to current regional conferences (SPS Zone 5, NCS-AAPT)
2013-2014	● have at least one member of the department serving as an officer in a national organization
2014-2015	● establish recognition in one national organization that mirrors current recognition within regional groups (i.e. NCS-AAPT, SPS Zone 5)
2015-2016	● have at least two members of the department serving as officers in national organizations

4. PLAN FOR STUDENT LEARNING ASSESSMENT

A. Student Learning Goals (4 to 8 goals)

1. Students will have conceptual understanding of mechanics, electrodynamics, and modern physics.
2. Students will be able to design, conduct, and present research with the assistance of a faculty member.
3. Students will be equipped with the mathematical and computational tools, as well as the content knowledge, necessary for post-graduate physics research. (B.S. recipients only)
4. Students will reflect on their learning to reassess their beliefs and attitudes relating to the physics enterprise.

B. Student Learning Outcomes (10 to 20 outcomes, 2 to 4 per goal)

1. Students will interpret physics demonstrations using the framework of Newton's Laws of Motion.
2. Students will solve problems that involve gravitational and electromagnetic forces.
3. Students will present science research with at least one poster and one slideshow.
4. Students will include error analysis and hypothesis testing in research results.
5. Students will read physics research articles and design experiments to confirm or expand the findings.
6. Students will write computer simulations of experiments conducted in the lab.
7. Students will begin to fulfill the role and carry out the duties of scientists in society.
8. Students will understand the history and significance of science as perceived by experts.

C. Course Map (Course map identifies degree to which course emphasizes outcomes)

	Goal 1 Conceptual Understanding	**Goal 2** Research	**Goal 3** Tools and Content	**Goal 4** Beliefs and Attitudes
PHY 221, 222	Primary		Secondary	
PHY 314	Primary	Secondary		
PHY 397, 398		Primary		Secondary
PHY 401		Secondary	Primary	
PHY 403, 404	Secondary		Primary	
PHY 410	Secondary		Primary	
PHY 499		Primary		Secondary

D. Assessment Plan

1. We assess students' conceptual understanding of mechanics and electrodynamics during their first year using two instruments: the Force Concept Inventory (FCI) and the Conceptual Survey of Electricity and Magnetism (CSEM). These are administered at the beginning and end of each semester. Elon student gain scores <g> are compared to the national averages for both traditional and interactive pedagogies.
2. We assess student research during public presentations. Students present their research from PHY 397/398 or 499 as part of the Spring Undergraduate Research Forum and at Society of Physics zone meetings. Members of the physics faculty review these talks afterward to evaluate the students' grasp of research and to determine which students would merit receipt of our Physics Research Award.
3. We assess content knowledge during the junior year using old versions of the Graduate Record Examination Physics Subject test.
4. We assess student attitudes on the relationship of their physics knowledge to real-world phenomena and how one makes sense of the natural world using the Colorado Learning Assessment of Science Survey for Physics (CLASS-Phys). These are administered at the beginning and end of the introductory mechanics course as well as the end of the introductory electricity and magnetism course. Additionally, we will administer this survey as part of the junior and senior assessments.

E. Document of Assessment (ARAP)

We have attached to this document the 2011 Annual Report of Assessment Progress. This illustrates how we will be documenting, reflecting on, and responding to assessment in the next five years.

5. CONCLUDING REMARKS

This five-year plan is both aggressive and viable. In the past ten years, our department has gone from almost no involvement with outside physics agencies to one that is recognized by our regional peers as an excellent physics program. In the next ten years, we intend to establish that same reputation at the national scale. Our goal during the next five years is to both improve our program to the quality of other nationally recognized programs and to increase our participation in national organizations in order to be recognized as such. Specifically, we hope to establish national models for our service learning through outreach, our four-year career building program, our excellent undergraduate research, and our unique dual-degree engineering option.