This annual report of 2011/12, represents the first year that David Tanenbaum has been chair of the department. It is also notable that it was the 47th and final year for Catalin Mitescu as a member of the faculty in Physics and Astronomy at Pomona College. In a similar vein, we have begun the design process for a new Millikan Laboratory which will be the home for both Mathematics and Physics and Astronomy for the next 50 years in the future.

Graduating Seniors in 2012

Physics Graduates 2012: Will Morrison, Catherine Wilka, Leo Rosetti, Zack Lasner, Eric Dodds, Emily Chang, Maira Amezcua, and Matt Hasling. Not pictured are Xinyi Guo and Garrett Pin.
During the academic year of 2011/12, our department of Physics and Astronomy graduated 10 majors, 2 minors, and has one student who has completed year 4 in the Caltech 3-2 engineering program. If you count Katherine Taylor, five of our eleven students in this class are women, three of whom are minorities (2 Asian and 1 Hispanic). Six of our students our headed into graduate programs all at highly respected institutions, including the most selective graduate programs in our field. Two of our students completed the astrophysics track, four have incorporated engineering courses in their programs, four completed double majors (3 in Math, 1 in Chinese), four speak Chinese, and one served as a writing fellow and ID 1 intern. Beyond academics, our students were active in sports, music, and outdoor programs during their time at Pomona. They are a terrific group and we look forward to their bright futures.

Summary profiles of each of these students and their plans are presented below.

**Maira Amezcua**  
Maira is a physics major who did a study abroad in Taiwan. She did three summers of research, two SURPs with Alma Zook and an REU at U of Oregon, where she will enter the Physics PhD. program this Fall. Maira worked as a mentor for physics 42 and a lab TA for physics 101. She was a department liaison as well. Maira’s thesis, “Quantum optics”, was primarily supervised by Alfred Kwok.

**Emily Su Chang**  
Emily is a physics major with a focus on engineering. She will begin a job with Google, Inc. starting August 2012. Emily completed 2 summer research SURPs with Dwight Whitaker, as well as an internship with a nanomaterials lab in Taipei, Taiwan. In addition she had a PCIP Internship with BOOM! Studios (comic publishing company) in spring of 2012. Emily was active in the department and cohosted Star Trek on Friday nights in the Planetarium as well as organizing creation of departmental T-shirts. Emily’s thesis, "A computational fluid dynamics analysis of Sphagnum moss", was primarily supervised by Dwight Whitaker.

**Eric Dodds**  
Eric is a double major in both math and physics. He will enter the PhD. program at UC Berkeley in physics with an interest in theory. Eric spent summers as an REU at CERN, and as a SURP with Dwight Whitaker doing experimental research on Bose Einstein condensates. He worked both as a mentor and lab TA for several courses in our department. Eric’s thesis “Progress toward BEC through optimization and measurement of a compressed magnetic-optical trap” was primarily supervised by Dwight Whitaker. Eric shared the Edmunds Senior Physics Prize with Zack Lasner.

**Xinyi Guo**  
Xinyi is an international student from China who is a double major in both math and physics in the astrophysics program. She will enter the PhD. in Astronomy at Harvard University focusing on theoretical astrophysics. Xinyi has done summer
research with Ann Esin at HMC, and her thesis “Applications of gravitational microlensing” describes work that has been submitted for publication. Philip Choi served as Xinyi’s Pomona thesis advisor. Xinyi shared the Brackett Prize in Astronomy with Catherine Wilka.

**Matt Hasling**
Matt is physics major with an applied physics focus. He will enter the PhD. program in physics at UC San Diego. Matt did two summers of research at Pomona, one with Alma Zook, and one with David Tanenbaum. Matt holds the record in our department for most courses as a teaching assistant, having held that role seven times. His thesis “An investigation into graphene growth and transfer methods” was primarily supervised by David Tanenbaum.

**Zack Lasner**
Zack is a double major in both math and physics. He will enter the PhD. program in physics at Yale University. Zack has done a wide range of research including summer research both at Pomona (with Richard Mawhorter and Dwight Whitaker) and at University of Maryland. His thesis “Towards BECs, the Bees Knees: A computational investigation of non ergodic evaporative cooling” was primarily supervised by Dwight Whitaker. Zack shared the Edmunds Senior Physics Prize with Eric Dodds.

**William Morrison**
Will is a double major in both Chinese and physics. He is pursuing science and engineering employment opportunities in the US and China. Will has worked on a variety of projects and did summer research at Pomona with Alma Zook, Alfred Kwok, and Philip Choi. His thesis “Building KAPAO-Alpha: A prototype adaptive optics instrument for Pomona College’s 1-meter telescope at Table Mountain Observatory” has been a major contribution to the NSF MRI funded program under Philip Choi.

**Garrett Pin**
Garrett is a physics major with a strong interest in environmental engineering. Garrett has spent the past year doing an internship with LivingHomes, a Santa Monica firm that makes attractive, modern, environmentally superior prefabricated homes. His main work has been comparing theoretical performance with actual performance of the buildings. His thesis “Design of a Solar Electric Assisted Human-Powered Vehicle (SEA-HPV)” was primarily supervised by David Tanenbaum.

**Leonardo Rosetti**
Leo is a physics major with a focus on engineering. He will enter the mechanical engineering master’s program at UCLA in fall 2012. Leo had a summer internship at Scripps’s Marine Physical Laboratory at UC San Diego designing and modeling probes for ocean studies. His thesis “Designing, Building, and Testing a dual axis azimuth altitude solar tracker” is the first research project using the new solar outdoor
laboratory on the roof of Pomona Hall. The thesis was primarily supervised by David Tanenbaum.

**Catherine Wilka**

Catherine is a physics major in the astrophysics program. While she is likely to pursue graduate work in the future, she has planned a gap year and is considering outdoor teaching and leadership programs such as NOLS. She has done extensive observational research including summers with Bryan Penprase using telescopes in Chile and Hawaii. She is already a co-author of a paper submitted for publication and her thesis “Analysis of low-metallicity damped Lyman Alpha systems using quasar absorption lines spectroscopy” is the basis for a paper in preparation. Catherine shared the Brackett Prize in Astronomy with Xinyi Guo.

**Katherine Taylor (not a graduate, but 4 years into a 3-2 degree)**

Katherine is a female physics major in the 3-2 Engineering program at Caltech. While she will not receive her Pomona College degree until next year, she has completed three years at Pomona and one at Caltech. Katherine is working at Caltech in the research group of John Dabiri, a MacArthur "genius" who came out to campus with Katherine this year to give a physics colloquium that was widely regarded as one of the best in recent memory.

While the focus here is clearly on the majors, we had two physics minors graduate this year as well, J. Evan Watts (major in environmental analysis), and Will Fletcher (double major in mathematics and chemistry), both excellent students.

Our class of 2012 was highly talented, diverse in both their backgrounds and their interests, and they are leaving well prepared for future plans which are as impressive as any class in the past.

**Student Learning Objectives and Assessment**

Our department continues to adjust our curriculum to match our learning objectives, which include the following key elements:

- **Students will understand the important conceptual models used in the core subject areas of physics and demonstrate their ability to correctly draw logical conclusions from these models and use them to make accurate quantitative predictions in realistic situations.**

- **Students will understand a broad range of experimental and data-analysis techniques and demonstrate their ability to use these techniques in both designing and conducting scientific experiments and observations.**

- **Students will develop certain fabrication skills useful in the field, such as the ability to design and construct electronic circuits and other experimental devices.**
• Students will demonstrate their ability to read, understand, and critically analyze the physical ideas presented in published textbooks and journal articles.

• Students will demonstrate their ability to present information clearly, logically, and critically, both orally and in writing.

• Students will demonstrate both understanding and the practical application of the ethical standards implicit in science, such as appropriate attribution of ideas, good record-keeping, and truthful presentation of data and conclusions.

• Students will be fully prepared for graduate study in physics or astronomy and/or careers in scientifically oriented jobs in the public or private sector.

An extensive discussion of the assessment of the senior exercise is included in Appendix A. Recent department reports have highlighted specific changes of individual courses. As a department we continue to evolve many of our courses, with these learning objectives in mind.

One area of growth in several of our courses has been in the development of student driven projects. These projects are able to engage students in several of our learning objectives far more effectively than traditional homework or laboratories driven purely by faculty interests. This practice extends to both laboratory and lecture courses, at both the introductory and upper levels, and also between major and non major courses. Students report tremendous satisfaction with these projects and the hours actively invested while long are rarely subject to complaints. The exception being when students have multiple courses whose projects overlap near the end of the term. We are looking at ways to limit the overlap of such projects which can be problematic for both students and our staff, who actively engage and support students with projects. We find another benefit of student driven projects is that they often broaden curriculum and stimulate curricular evolution. Even in courses where the projects have a long history such as Electronics, we see an evolution, where beyond simply completing the project, now students carefully craft videos describing and demonstrating the projects and post them to youtube or compete in national competitions. Overall, beyond the positive energy student driven projects bring to our program, they also empower students, and this seems to have a direct and positive impact on approaches to research. Projects have so much appeal that some students have taken on similar projects with departmental support outside of our curriculum. In many cases project based learning is akin to a capstone exercise within a single course, and can be the ultimate in active learning, which is recognized to be the most effective way to learn physics. It cannot be emphasized enough that the uniqueness of a student driven project makes it a far more interesting topic of conversation than traditional assignments in lecture or laboratory courses, and can be the basis for a successful interview for students applying to internships, REU programs, or competing for jobs in the public or private sector. Overall these projects
support most of the learning goals outlined above, particularly those that are not as easily addressed with traditional coursework.

**Trends in Enrollment and Majors**

Enrollment trends in our department are presented below with total enrollments in Physics and Astronomy versus time. Physics enrollments (green) and Astronomy enrollments (blue) are both shown. There are many ways to count enrollments, but the data shown here were taken directly from the *Diversity in the Major* spreadsheet provided by the Dean's Office via Sakai.

*Enrollment trends for each academic year from 2006-2012, including total physics and astronomy enrollments, showing total physics enrollments (green) and astronomy enrollments (blue). Data taken from the Dean's Diversity in the Major spreadsheet.*

The decrease from 2011 to 2012 is largely connected with enrollments in the general physics courses, 41/42 and 70/71/72. Some of this is a direct result of the number of lab sections we
can staff for the 41/42 sequence. We offered (and filled) 4 sections of Physics 42 labs and 3 sections of Physics 41 in AY 2010-2011, but only 3 sections of each in AY 2011-2012. While many things influence enrollments in these courses, the change in the Biology curriculum where Freshmen take Biology in the Fall is probably the factor with the biggest impacts that we do not fully understand yet. Our sequence of offering 41/42 in a Spring/Fall format was based on historical patterns that best suited pre-medical students before the curricular changes in Biology. We are watching the enrollment patterns to see if this needs to change. The enrollments in Astronomy show a recovery from the AY 2009-2010 when Philip Choi was on leave without a Steele Leave replacement. It should be noted that several of our major track courses (Physics 125, 128, 160, & 170) were at record high levels in AY 2011-2012.

Our total number of Physics majors as a function of their graduation year, based on either completed majors (Spring 2006-2012) or declared majors (Spring 2013 and 2014) is shown in the blue bar graph below.

![Number of Physics and Astronomy graduates since 2006, as a function of graduation year. The plot presents completed majors for past years, and declared Physics majors for the upcoming years ('13+'14).](image)

Overall we ended AY 2011-12 with 35 declared majors including 11 women, 6 minorities, 10 graduates, 1 student at Caltech, 10 rising seniors, and 14 rising juniors. While there is always room for growth, this data clearly suggests we are moving in a positive direction. If the
declared majors hold or grow for 2014 it will be the biggest group of majors in our program since 2001. That year we graduated 15 physics majors, which may be a record for our department. We recognize that we need to continue to work on diversity in the major not only in terms of racial and gender issues but also in terms of career paths. One area where we need to focus is demonstration of support for students pursing our major who are not focused on graduate programs in physics. We have worked this year to revise our documentation for guidance of majors emphasizing the flexibility we have to support a variety of students such as those starting the major in the sophomore year, and those interested in careers in engineering, teaching, medicine, law, finance, etc. In addition, we have been bringing a wide diversity of our alumni into our senior seminar via Skype to explain their career trajectories and answer questions for our students.

Statistically, a 3 year running average of more than 11 majors (34/3) suggests our program would be in the top 7% of Bachelor’s-Only Physics departments in terms of production of Physics Bachelor’s, independent of our total student body or FTEs according to the American Institute of Physics report, Focus on Size of Undergraduate Physics Programs.

Distribution of ethnic diversity in Physics and Astronomy enrollments (green) compared with the college wide enrollments (blue). Data taken from the Dean’s Diversity in the Major spreadsheet. Differences for Asian, Hispanic, and Unknown students are statistically significant.

Our department held a recent retreat where we discussed both the diversity and overall enrollments extensively. We agreed that while we are doing well, we can envision the growth
continuing, largely through focused efforts to enhance our diversity. A comparison of the ethnic distribution of our enrollments to that of the entire college shows that for white and multi-racial students the distributions are the same. The asian and the unidentified students show a higher representation in our enrollments, and the black, hispanic, and nonresident enrollments are under represented in our enrollments. While college-wide enrollments by women exceeded those of men, 51% to 49%, in Physics and Astronomy enrollments men exceeded women 59% to 41%. There is a national push to increase the minority enrollments in STEM fields, and as the predominant pathway to pre-engineering at Pomona, we see significant untapped potential to bring more hispanic and black students into our courses. We are working to make our program more attractive for these groups, and to enhance the visibility of our applied programs. We believe the applied programs will help place our graduates into the next generation of the STEM workforce which is seen as a key to the future of the American economy. Daniel Contreras (‘13) received a 2011-2012 American Physical Society Scholarship for Minority Undergraduate Physics Majors this year, and we will continue to nominate students for these national awards. While we have students in Engineering programs at both Caltech and Washington University in Saint Louis, we are actively exploring other engineering programs that might be more attractive such as the 2-1-1-1 program at Dartmouth. We also should better publicize our success with students who complete our Bachelor’s and then enter 1-2 year Master’s of Engineering programs.

We brought in Dave Belanger from UC Santa Cruz to give a physics colloquium this year, and after the colloquium he met with members of our department to discuss the tremendously successful NSF funded program at UCSC to bring in minority students from regional junior colleges. As we discuss growing the size of Pomona College, he would argue that junior colleges are a resource we should be using. The keys to the UCSC program are that in the recruitment phase they bring entire families to campus, and that they provide significant additional support for the students when they arrive through their NSF grant. This support includes both social opportunities and programmed tutoring sessions. At Pomona, this might be a natural fit for a collaboration with the Draper Center and the future Quantitative Skills Center.

It is established that having diversity in the faculty helps foster diversity in the major as well. We ran two very late searches for visiting instructors for lab sections for Physics 41/42 in AY 2011/12, which brought excellent instructors to the college, but did not enhance our diversity profile. However, with more time to search for three visitors starting in Fall 2012, we searched as broadly as we could, and in Fall of 2012 we will bring international women to our department for 2 of the 3 visiting positions. The third position will return our strongest visitor from last year, who received excellent evaluations from students.
Developments in Research in Physics and Astronomy

Research activity continues to blossom in the department of Physics and Astronomy. We have continued success with NSF grants through the MRI program with a new grant led by David Tanenbaum for $546,273 to upgrade our electron microscopy facilities. The new instrumentation should be in place this summer, and will be used by students from physics, chemistry, geology, engineering, biology, and art across the Claremont consortium. All our faculty are engaged with students who have helped make new advances in our research programs. Philip Choi’s NSF funded adaptive optics program for the 1-meter telescope reached a major milestone by making the first closed-loop active-correction “on sky” this year. Bryan Penprase has multiple papers in preparation from his collaboration on Near Earth asteroids and new data for the basis of a paper on quasar absorption line spectra with student co-authors. David Tanenbaum has 3 papers published and a fourth submitted in 2012. His students have designed, built, and installed a new 2-axis solar tracker on the solar deck of Pomona Hall for solar cell stability studies. Richard Mawhorter continues to bring students to Germany to perform microwave spectroscopy measurements to search for the electric dipole moment of the electron. Alfred Kwok is working with students to add Raman spectroscopy to his TIR fluorescence microscopy system for studying processes in cell membranes. Dwight Whitaker and his students have created a new model of the ejecta from Sphagnum moss that now enables them to apply this model to new research problems in fluid dynamics. Alma Zook and her students are making polarization measurements of blazars using the 1-m telescope as part of larger collaboration on blazar research. Thomas Moore’s new textbook for undergraduate general relativity (GR) courses has gone into press, and he has a new very high profile paper on teaching GR to undergraduates in Physics Today this month.

Physics and Astronomy Public Events

The Physics and Astronomy department has worked hard to create strong bonds between students, faculty, and staff. Weekly events included a Monday Physics lunch, Friday Star Trek screenings in the planetarium, and a joint colloquium series with the Harvey Mudd Physics department. Special events this year included a retreat to Halona, sailing and kayaking at Bonelli Park, monthly birthday celebrations, a Binary day celebration in collaboration with math and CS on 10/11/11 = 47, a department awards banquet and an alumni weekend open house honoring Catalin Mitescu’s 47 years of service. Much to our
surprise “Physics Phest” our festival of Physics in the Arts had to be cancelled due to rain during the year when “water” was the element theme at Pomona.

In addition to these departmental events, Bryan Penprase developed and hosted the Southern California PKAL conference focused on advances in STEM education. This was a major event with excellent speakers and opportunities for significant interactions from a wide range of faculty at both public and private institutions across many disciplines.

David Tanenbaum and David Haley hosted over 20 area high school physics teachers for the Pomona College CIPT workshop “Thin Films and Circuits” with support from Marty Alderman from Cornell University. Teachers attended lectures and were trained on two new laboratories with full class sets that can be checked out from the Pomona CIPT Lending Library.

It was a banner year for public astronomy events held at Brackett Observatory. These events are tremendously popular with hundreds of attendees from the colleges and the community. Led by Bryan Penprase and Philip Choi, and supported by students, staff, and faculty, this year’s events included:

- June 5, 2012 - Venus Transit open house
- May 9, 2012 - End of semester open house viewing Saturn
- April 6, 2012 - Open house to view Venus and Jupiter
- March 28, 2012 - open house which was cancelled but ~60 people showed up anyway.
- February 2, 2012 - open house
- October 27, 2011 - open house with live music and Art After Hours collaboration

Future of the Department

We have held a variety of events together with the Mathematics Department, Facilities and Campus Services, Jonathan Wright, and architects to discuss the future of our building. This once in 50 years opportunity is tremendously important to do well. We are enthusiastic about the selection of the firm EHDD. In the longer term we hope the new building will be not only enhance our existing programs, but inspire new ones as well. One example of this is the physics outdoor laboratory, a science museum playground inspired space where students experience physics directly with their own bodies. We anticipate a variety of new educational outreach programs when the long awaited project becomes a reality. We look forward to returning to a vibrant state of the art center for learning and research on our campus.

In preparing for the future we should begin a departmental self study in preparation for an external department review. Our last self study and external review was completed in Fall
@2003. Our department curriculum, faculty, staff and research programs have changed dramatically since our last review in 2003. The approaches to physics education at a national level have changed as well.

With the retirement of Catalin Mitescu who has been a frequent contributor to our courses in Mathematical Methods, Fluid Dynamics, and several laboratory programs we must consider some potential curricular changes. Future retirement of other faculty members is inevitable and we should begin to prepare for this now given the limited nature of faculty positions at the college within the college.

At the recent Physics and Astronomy faculty retreat we went around and shared visions for the future of the department. Some of these visions have come up earlier in this report, such as approaches to increasing the diversity of our majors. Here are some aspirations for the future that have not been mentioned:

- Bring outreach programs into the physics curriculum rather than outside it
- Create new interdisciplinary courses and curricula across departments
- Participate in the creation of the new Quantitative Skills Center
- Participate in the creation of a new “bridge” program for disadvantaged students
- Develop more regional ties to other scientific institutions
- Bring in new NSF grants for both research programs and revision of laboratory courses
- Develop new partnerships for engineering oriented students
- Increase flexibility within the major requirements
APPENDIX A - Assessment of the Senior Exercise

The senior exercise in the Department of Physics and Astronomy consists of 3 major pieces: a senior seminar course, a comprehensive exam, and a senior thesis. All of these pieces have been revised substantially over the past ten years, and that conversation continues every year.

The senior seminar:

We rotate faculty though the senior seminar which is co-taught by two faculty members to give a broader perspective than any one of us could provide. Co-teaching extends beyond the lead faculty, as thesis advisors also participate in guiding students in relevant assignments. Seniors get a significant variety of feedback from both faculty and their peers. In Fall 2011 Bryan Penprase and Philip Choi led the seminar. Prof. Penprase provides a nice update on the most recent rendition of the course in his PAR which is excerpted here:

Our team effort continued these improvements, which allowed students to study for their Physics GRE, prepare introductory chapters of their thesis, explore career options after graduation, and discuss the latest news in Physics and Astronomy. We arranged the class to have three major written assignments, each accompanied with a presentation to the class. Guests included representatives from the CDO, Teach for America, and for the first time we arranged alumni panels to discuss life after Pomona with the students. These panels included recent graduates that are currently employed in capacities across the spectrum of Physics and Astronomy. Some are enrolled as PhD students at Harvard, and Yale, while others work as engineers at Edison, a company in Colorado and the Aerospace company, while still others are law students and entrepreneurs. Using these skype panels for our seniors greatly enhanced the reach of our course, and the range of careers our students could contemplate, and I recommend this approach for other departments.

Highlights of the Fall 2011 Physics 190 class included:
• Two alumni panels which allowed students to talk with 9 recent graduates living across the country (via Skype) during our 9:00AM class time.
• Good integration of speaking and writing intensive assignments in the class
• Use of our new alumni database from the department to give students good contact with the outside world.
• New assignment for students to conduct phone interviews with 3 alumni and report back on “Life outside the Pomona Bubble”

Assessment of the student work in the senior seminar is almost entirely up to the two faculty associated with the course, with minor consultation from thesis advisors. However assessment of the senior seminar course itself is discussed among the faculty as a whole at department meetings. The results of these discussions are then incorporated into changes by those teaching the seminar the following year. We do this by providing continuity as we
rotate the faculty, so next year Philip Choi will continue on as an instructor, and Bryan Penprase will be replaced by Greg Ogin a visiting faculty member whose recent experiences should be a great addition to the course. Some of the changes come about because as a group our expectations for the standards for the quality of both written and oral work have risen significantly over time. While we believe the course has been a tremendous success, we recognize that it must constantly evolve to serve students well, as expectations for senior theses, formal and informal presentations, and career paths are not static, but dynamic.

**The comprehensive exam:**

Historically the department has always had a written comprehensive exam as part of the senior exercise. More than in any other field, the GRE Subject Test is used by Physics graduate admissions programs to compare students for admission. The exam is valued because it is a standard that can be applied to an otherwise diverse pool, despite the recognition that it is not a perfect measurement tool. Preparation for the GRE is quite different from the typical exams given in our courses, and the dissonance between the GRE and our traditional exam was problematic. About ten years ago our department recognized this and we replaced our exam with the GRE Subject Test in Physics. The benefits to students going forward to graduate programs (both immediately or after a break from academic work) have been substantial. These students appreciate the value of the exam and should be taking it any case. By enhancing its presence in our curriculum, it has certainly helped them. From a departmental perspective, the exam gives us very useful assessment of our preparation for graduate school bound students. As a comprehensive exam for all majors the issue has been how fair or reasonable is it for our students who are not physics graduate school bound to be tied into competing at a national level with physics graduate bound students. In the first few years we did not have any idea how such students would fare. While ETS provides the scaled scores and percentile rankings, the interpretation is challenging, and initially we simply required the exam to see what the patterns would be. After several years worth of data were in hand we discussed extensively as a department if we should implement a minimum passing score for this part of the exercise. About 4 years ago a passing mark at the 25th percentile was established after extensive debate by the full department. A consequence for failure was put in place, not to retake the exam, but to work through a series of problems under the guidance of a faculty member. While this has worked to some degree, it is still an actively being assessed by our department. After an extensive department discussion Philip Choi created a histogram with Physics Subject Test GRE percentile ranked scores sorted into two categories physics grad school bound (blue) vs. our non-physics grad (green) from the last two classes (N=17). As is clear from the histogram there is a big difference in the distributions of the two groups. While not inherently a problem or unexpected, there is a sense that we might find a better
Distribution of percentile rankings on the Physics Subject Test GRE for graduates in 2011 and 2012. The physics graduate school bound students (green) are compared with those who are not (blue). There is a significant difference in the two histograms.

comprehensive assessment for those students not bound for physics graduate programs and we are actively discussing options. It is clear that the goals and motivations for students in the two groups is significantly different. In particular, while the data are useful in many ways, the experience for the non-physics graduate bound students is neither satisfying nor empowering. This is the same group for which we argue we want to enhance the experience in the major, a clear contradiction.

David Tanenbaum recently attended conferences at the APS and led a discussion on standardized exams in undergraduate Physics. In the field of Chemistry there are standard tests provided by the American Chemical Society, but there is no equivalent tests from the American Physical Society at this time. Many institutions use the ETS Major Field Test for Physics (http://www.ets.org/mft/about/content/physics) which is given to all students, not simply those bound for physics graduate programs. The test is cheaper than the GRE, given online, and has many other potential benefits as an assessment tool. We will explore this further in the coming year. Since the tests are offered in 15 major fields, it would be interesting to know if any departments or programs at Pomona have experimented with it.
Beyond the ETS corporation there are a wide range of tests developed by the researchers in physics education, which are used in studies of effective teaching methodologies. We historically use one of these, the FCI to evaluate our introductory courses. Others may now be available that could be useful if we change our comprehensive exam system away from the GRE for some or all of our students.

**The thesis:**

All our majors are required to write a senior thesis. We allow a half course library thesis in some situations (such as students working on engineering clinics at HMC) but almost all our students do a full course thesis. Many begin this research much earlier in their academic careers working in laboratories both in summer and during the year, but the thesis must focus on work done during the senior year. Some theses are theoretical, some are computational, some are pedagogical, but most are experimental. All require significant original effort and have a primary faculty thesis advisor. Several years ago we made a conscious effort to inspire the majority of students to do thesis research projects that connect with our own research programs and this has become the norm rather than the exception. The result is overall theses that are better conceived, advised and supported than before. In addition to the written thesis we currently require an oral thesis presentation. This year we had significant discussion at a department meeting about the importance and effectiveness of these oral presentations. We considered the model of a poster session for most students and a longer presentation for only a subset of the theses. At this point there is not a clear consensus if that model would be better.

Our faculty always ensure that each thesis has at least two readers, one being the primary thesis advisor. We assess the theses at a department meeting where each advisor leads a discussion of their student’s theses. This is followed by comments from secondary readers and the rest of the department. A printed copy of each thesis is on hand in the room during the discussion, and is frequently cited and examined. While we don't all approach the evaluation the same way, we do discuss the quality of the research itself, the initiative taken by the student, the quality of the written thesis document, and the quality of the oral presentation. Typically this will result in a tentative grade range for the thesis in question. The faculty repeats this for all the students in the graduating class. At that point the full faculty re-examine the relative grades in an attempts to finalize the appropriate grades. This point in the process often involves some informal comparisons of a given year’s theses with those from prior years, particularly at the extreme ends of the distribution. The full faculty discussion lasts 1-2 hours.

Overall our assessment of the senior exercise is thoughtful and deliberative. We have excellent discussions with a collegial atmosphere assessing the students and our process.