Introduction
The task of educating Physics and Engineering students is a complex process that depends, not just on the department or even the academic area but the college as a whole. Beyond the core of physics/engineering courses, the mathematics, chemistry, computer science as well as humanities and social science courses are critical to their academic development. Off campus programs, student life and the chapel program also are part of the essential college experience. We depend on all these areas. Any departmental planning must begin with the understanding that we are part of a whole. That said, this document focuses primarily on our role in the process, and how we can improve our part of the process. We have identified three goals for assessment and improvement in our program.

Three Primary Areas
The first area is in classroom teaching. Both physics and engineering involve developing analytical and abstraction abilities as well as learning a great deal of content. This is done in the classroom and on homework and exams. It is a sequential process, layering knowledge on knowledge. In some areas of the college a freshman could, in principle, take a senior level course. There is, however, no way that could be done in the physics, owing to the highly sequential nature of the subject, and its increasing level of abstraction and complexity. So weakness in any level affects all levels above.

The second area is in laboratory courses. Both physics and engineering require, in addition to head knowledge, the ability to work with scientific equipment, make measurements, do experiments and interpret and write up the results. The laboratory courses play a critical role in developing these skills. Often lab courses are connected to lecture courses to give hands-on experience to the theoretical topics being taught.

The third area is in developing greater opportunities for student research and practica. By the time students graduate they should have “real world” experience in doing physics and engineering. For physics students this primarily means gaining experience in research with a faculty member. For engineering students this more likely means getting involved in an internship or practicum in conjunction with a local research and development company.

1. Classroom Teaching
Specific Focus: Training and Assessment Undergraduate Teaching Assistants
In the area of classroom teaching our present focus is on the training of our undergraduate teaching assistants. A great deal of student learning can potentially take place during review sessions with a TA. The selection of students who will serve as teaching assistants is conducted with great care by department faculty members. The ideal candidates for these positions are mature students who have performed at or near the top of their own class in the subject, who have the ability to articulate the concepts clearly, and who can understand and address points of student confusion effectively. TA sessions are scheduled in the evening, and student attendance is optional. These sessions often occur on the evening before homework sets are due. The role of the TA is primarily two-fold:
To clarify and strengthen concepts learned in class
To assist students in the development of problem solving skills

The teaching assistants also benefit greatly from the process of teaching others. Their own understanding of the topic is broadened considerably when they are put in the position of helping their own peers understand the material better. For some, it may spark interest in a teaching career; at the least it exposes our best students to an experience outside the classroom that builds confidence and ability in public speaking, and deepens their own understanding of the subject in a way that only comes through teaching it to others.

Strategies for Implementation

1. **Selection of teaching assistants:** The process of selecting students who will make effective teaching assistants is an important one. Teaching assistants need to have mastered the material and have the ability to think and speak on their feet. They need to care about their teaching and about their fellow students' learning in order to do a good job.

2. **Training of teaching assistants:** Currently, each professor works individually with his or her own TA. We are currently developing a structured training program in which all of our TAs would participate, in order to bring greater quality and consistency to the teaching assistants' performance. This program would include instruction in the principles of teaching, helpful ideas and tips about effective teaching, etc., but in such a way as to allow each student to develop his or her own personal style.

3. **Modeling good teaching:** We will encourage our TAs to observe our own teaching as we respond to student questions and help develop problem solving techniques.

4. **Ongoing Guidance for TAs:** We will observe how effectively the TAs develop in their skills. We will solicit feedback from classroom students, and occasionally attend some TA help sessions to provide feedback for improvement.

5. **Evaluating TA performance:** In the end we need to evaluate the performance through course surveys that allow the students to rate the TA in a number of areas. This would be combined with our own first hand observations in order to provide an accurate evaluation.

Measures of Progress

1. **Establishing a baseline:** We are developing a survey that will be given to students to evaluate our current crop of TAs to see how they are doing. In this we will look both at TAs and graders.

2. **Establish a file for each TA:** We will document the criteria used for the selection of each TA, note when training was done, note interactions with faculty (both our observing sessions and any meetings to discuss teaching. Student evaluations will be included in their file. This can form a basis for future teacher recommendations as well.

3. **Quantify the course evaluations on the TAs:** We would track over time the performance of our TAs. We would look both at the semester by semester improvement of our TAs but also the progress of the program.

4. **Each year seek feedback from TAs:** We would invite TAs to contribute their own observations and suggestions as they go through the process.
Specific Focus: Laboratory Logbook and the Writing of Experimental Abstracts

Scientists maintain laboratory logbooks for recording details of their experimental work and analysis (which can become essential in the establishing of original research credit, resolving patent disputes, etc.), and eventually report their results in peer-review journals. Our current focus in the area of laboratory instruction is on training students in the efficient use of their laboratory logbooks, and on the development of “publication quality” write-ups of their experimental results. The laboratory logbook is used for recording scientific observations while experiments are being carried out. Students use it each week to record important information concerning their work, including notes taken during the pre-lab discussion, sketches and notes on the apparatus, any data or measurements taken, peculiar observations to which they may need to at a future time, etc. The quality and quantity of information in the logbook should be sufficient to enable the experiment to be repeated in the future by someone else. We periodically check students’ use of their laboratory notebook book.

The experimental abstract, on the other hand, is a concise, informative overview of the finished experiment, with a brief summary of results and conclusions. It forms the first impression of the work, and so it carries great importance. It is to be addressed it to a scientifically literate audience. It includes a brief statement of purpose, description of the experiment, analysis, results, and conclusions. The abstract plays a very important role in the scientific literature, serving as a “bird’s eye view” of the paper, providing the reader with a grasp the main content at a quick glance. Training our students in the writing of good abstracts will prove an indispensable tool in their future scientific careers.

Strategies for Implementation

(1) Clear expectations up front: In the first lab of each semester we will lay out what is expected in lab write-ups. This will include a list of requirements along with an example of a well done write-up.

(2) Focus especially on the abstract of the full lab write-up: The scientific abstract will pull everything together in a brief, informative overview, and writing it will help the student in making clear, logical sense of the whole.

(3) Progressive, prompt feedback: The student’s will have 2-3 days to complete their write-ups and the labs will be graded with feedback comments in time for the students to have at least a day to review them before the next lab.

(4) Progress from maintaining a lab book to writing a scientific paper: There is a substantial style difference between the two, and training students in both areas is important.

Measures of Progress

(1) Establish a baseline: Our plan is to compare results before and after special attention is given to this writing process. We are therefore in the process of maintaining some typical student lab books and papers to compare with future work. In Fall 2006 we began assembling this database, which includes baseline work as well as work reflective of this progressive system of feedback and improvement.

(2) Maintaining portfolios: Each student will save his/her work, but the department will make copies of students’ logbooks and lab reports to monitor progress through time. The abstracts will command special attention.

(3) Compare successive laboratory courses: Students should improve not just within a course but each successive course should show improvement. Thus a portfolio that spans all their lab courses will be maintained.

(4) Student feedback: We will ask students to evaluate the program as a whole and also their individual progress in a way so as to not affect their grades.
3. Student Research and Practica

Arguably the single most important factor in influencing an undergraduate’s future plans in science is the opportunity to conduct research with scientists. The most fundamental understanding and appreciation of science is achieved not through classroom instruction or the reading of textbooks, but through the apprenticeship-type experiences of conducting research one-on-one with trained scientists. Working with scientists and instrumentation provides an authentic scientific experience, something the classroom cannot fully provide.

Our department has had a long history of providing students opportunities to conduct research with faculty. Each of the three physics department faculty members have held National Science Foundation grants (as well as others) with which to employ students in research. Students have conducted research in superconductor physics, theoretical nuclear physics, and (at present) in experimental nuclear physics and astronomy. Once the Keck grant project for the Carroll Observatory upgrade is complete, new research opportunities will be available for students using that facility.

We have also had great success in placing students in practicum projects with scientists at local hi-tech firms (Santa Barbara Research Corporation, Raytheon, Litton Guidance Systems, among others). These experiences give the engineering-oriented students experience working in an industrial environment, which can prove invaluable to them as they explore future career possibilities.

Strategies for implementation

(1) **Off-campus research opportunities**: The National Science Foundation’s “Research Experience for Undergraduates” program at participating universities and laboratories selects students on the basis of merit, and provides stipends and free housing for approximately 10 weeks of research. The varieties of experience they gain moves them far beyond what they learn in class, and equip them with tools and methodology they will carry with them into the next phase of their careers.

(2) **Off-campus internships**: For the engineering oriented students, we maintain a database of local companies expressing an interesting in enlisting practicum students, and put them in touch with those that have good overlap with their interests. Students receive pay and/or course credit for their work. Goals of the project, as well as final grades are determined in consultation with the company scientist serving as mentor for the student.

(3) **In-house research opportunities**: for physics students will require that we maintain sources of external funding (for travel, equipment, stipends, etc.). However, we also hope to increase the amount of internal funds (departmental, local foundation-funded, etc.) available for use as summer stipends. Currently we are able to support around ½ to 1 summer position through departmental student employment funds. As the observatory facility comes online and begins to be used for research, we plan to apply for external funding through the NSF or NASA.

Measures of Progress

(1) **Honors projects during the students’ senior years**: For our best students the research done in a senior honors project is a stepping stone to success in graduate school.

(2) **Student names on publications**: The ultimate “validation” of scientific work

(3) **Students accepted to present research at national conferences**: This is recognition of work done as well as valuable experience

(4) **Graduate school entrances**: which these days depend heavily on research experiences gained by the applicants.
(5) **Database of student researcher activities and their projects (encompassing the points above):** We will keep track of student names on professional publications, presentations at local and national conferences, graduate school entrances, etc. Additionally we will compile statistics on what other schools across the nation are doing and how Westmont compares with similar institutions. From this information we ought to be able to demonstrate in tangible ways the effectiveness of research experiences for undergraduates.

(6) **Student posters prepared for national conferences:** We are currently keeping and hanging them in the department to publicize some of our students’ noteworthy accomplishments to other students and staff, in hopes not only of highlighting student accomplishments, but inspiring future student researchers.

(7) **Feedback from graduates:** We are currently developing a survey which will be administered to students several years out from Westmont, both for those in graduate programs as well as those in the workplace. Our goal is to determine the roles that student research and practicum experiences play in helping determine future student success in graduate school, industry, scientific laboratories and educational institutions. We will maintain a database of this feedback as an indicator of effectiveness.

(8) **Feedback from industry mentors:** For the students who participate in local internships we will keep copies of the written reports provided by the industry mentors. So far all we have is verbal anecdotes of success, and we plan to formalize the feedback mechanism so that we can maintain a database through the years.

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**Current State of Progress**

**Classroom Teaching - The training of teaching assistants**

- **Spring 2006** – We are in the process of establishing a baseline for this assessment, and plan to administer a mid-semester and end-of-the-semester survey to our Physics of Music, General Physics, Physics for Life Sciences, Mechanics, and Electromagnetic Waves and Optics classes.
- **Fall 2006** – We will begin implementing a formal TA training program which is currently under development.

**Laboratory Instruction - logbooks and the writing of experimental abstracts**

- **Fall 2004, Spring 2005** – We have a collection of sample student logbooks and experimental abstracts for comparison purposes.
- **Fall 2005, Spring 2006** – We have been working more concertedly with students, training them in the proper use of their logbooks, and in the writing of high quality experimental abstracts. We started building a file with student abstract examples, chronicling their progress throughout the course of the semester. These samples can then be compared with our collection of previous student work.

**Student Research and Practica**

- For several years now we have been maintaining a record of specific student research projects in the department, as well as names of students appearing on author lists of professional publications, and student presentations at national conferences.
- **Spring 2006** – We are beginning to collect statistical information on student involvement in scholarly research at several other similar 4-year liberal arts institutions for comparison purposes. The American Institute of Physics also maintains extensive databases of information helpful in determining the effectiveness of our research and practicum offerings for students.
- **Spring 2006** – We are working on a questionnaire for students who have graduated from Westmont over the years. We plan to begin implementing the questionnaire later in the spring semester.