DEPARTMENT OF PHYSICS

ANNUAL UPDATE REPORT – JUNE 2006

PROGRAM GOALS

Our three goals in the Physics Department, as listed in our February 2006 report, are

- Classroom Teaching – with a special focus on the training and effectiveness of our departmental teaching assistants.
- Laboratory Instruction – with a special emphasis on the writing of student abstracts summarizing experimental results and conclusions
- Student Research and Practica – with a special emphasis on the training of young scientists in preparation for graduate school and career

In the sections below we briefly summarize these three goals. For a more complete description of these three goals, please refer to our departmental report of February, 2006.

DEPARTMENT GOAL #1 - CLASSROOM TEACHING AND THE TRAINING OF DEPARTMENTAL TEACHING ASSISTANTS

Program Goals – In brief, the goals of our TA program are

1) to increase students’ understanding of course material by supplementing their classroom experience with a once or twice weekly session with one of their upper-class peers. This less formal setting enables students to ask questions for which there is less time in class, and will strengthen their understanding of the course subject matter and improve their scientific problem solving abilities.

2) to provide the gifted upper class students opportunity to teach their peers, and in doing so deepen their own understanding of the subject matter and increase their ability to articulate it in a public setting. Their grasp of the topic is broadened considerably when they are put in the position of teaching others and assisting them in better understanding the course material.

Student Outcomes – By administering our departmental TA survey (see below) each semester, we build a database of numerical and written responses to questions regarding the overall experience of students. Comparison of results before and after the installation of our TA training program (to begin Fall 2006) will provide us a measure of success of our efforts. Ongoing monitor of survey results supplemented by informal conversations with students and TAs will provide us additional feedback for improvement of our TAs and the training we provide them.

Data - We conducted an initial survey in May 2006, covering courses taught in Fall 2005 and Spring 2006 to serve as a “baseline” for the implementation of our TA training program. The survey tool, as well as numerical results, are listed in Appendix A of this
report. This same tool will be used in subsequent semesters to monitor the effectiveness of the training program.

Some basic observations at this initial stage include the following.

**Interpretation of the Results** – None of the students who were reviewed for classes in Fall 2005 and Spring 2006 had any formal TA training. Each had a brief session with his or her advisor at the beginning of the semester, with little follow-up throughout the semester except on occasions where student concerns were expressed. It is worth noting that two of the classes, PHY-011/13, PHY-021/023 and PHY-040 had exceptionally capable TAs that needed little training. It would appear that teaching came quite naturally to them. We are not surprised at this, since there will occasionally be those who fall into the roll quite naturally (and who are therefore most likely to be selected at TAs). The training program is designed to benefit all TAs, regardless of innate ability. The department goal is that there be greater uniformity across the curriculum, and that all will benefit from formal training so that the experience is more fruitful for all concerned, students and TAs alike.

Numerical results of the survey (Appendix A) indicate a broad range of TA quality, with the main sources of concern centering on preparedness and timeliness. On the surveys revealed a few common concerns, regarding TA preparedness, timeliness, and improvement of “people skills,” referring primarily to attitude toward the class students, and patience with the questions asked. As an example of what we might consider a TA of “average” ability, the histogram below shows some areas of moderate concern. If we use 3.5 as a threshold score, he fell below that mark in the following areas, as judged by the class students: interest in the subject matter, showing up on time (and even showing up at all!!), being clear in his explanations, and being prepared. The scores on these items are not alarmingly low, but certainly point to the need for training.

Another concern (and one with which we are well aware) is that sessions often degenerate into students requesting confirmation of the final numerical answers in order
to check their own homework solutions, or worse, students simply asking the TAs to work through entire problems (and TAs acquiescing!) so students can copy down the solutions, leaving little time for addressing the root sources of students misunderstanding. A departmental goal for help sessions is that the TA field questions, ascertain weakness in students’ understanding, and help them work through problems through creative means that avoid actually working the problems through to completion, in order that students can then return to their own work with improved understanding. This will be one of the greatest challenges of TA training, since the path of least resistance for the TAs is often to simply lay out the general solution for students, which benefits neither the students or the TA.

Written comments largely reflected the same concerns expressed in the numerical responses. An additional item emerged from an informal conversation we had with several class students on this topic. Students expressed an interest in the TAs being able to start review sessions with a brief overview of the material covered in recent classes. We will consider encouraging the professors to provide the TAs with a brief outline sheet to be used for this purpose.

Using the Results – The results of this survey will directly assist us in the development of our TA training program. After discussion of the results in our department, our department is currently developing a plan for Fall 2006 training based on results of the recent survey. Major emphasis for this training will address

- Training on two levels – teaching and problem solving. We would like to include some light-hearted material, such as our participating in short skits illustrating some of the common problems that typically emerge in TA sessions, and their solutions.
- the importance of TAs going to the sessions fully prepared in their own understanding of the problems (survey items #3 and #12) (TAs often don’t review the homework solutions until just before the session – and this is sometimes the fault of the instructor providing solutions late),
- helpful suggestions on how to uncover and discern root sources of students’ misunderstanding of the course concepts (survey item #5 and #10), learning how to ask leading questions that help tease out the sources of student confusion
- techniques on helping with homework problems by reviewing and strengthening relevant course concepts, without simply working through the entire solution (survey item #11)
- the importance of showing up each for each session on time, regardless of whether classroom students are present when they arrive (to this end we will make sure they know that they will be paid for the first 20 minutes they wait for students, if none eventually arrive) (survey item #8 and #9).
- Basic problem solving techniques, and how to best present these in a pedagogically helpful and constructive fashion.
• Emphasis on importance of timeliness, courtesy, and patience with the students. Also helpful would be helping them to deal with difficult students. This can be a tough area for TAs deal since they are teaching their own peers.
• Providing them space to practice their skills in “mock” sessions where we ask the questions and assist them in their responses.

**Next Steps** – We are implementing a TA training program in Fall 2006. Once the training program is in place, we plan to share the general results of the questionnaires with the class TAs in order to give them constructive feedback. We will also solicit their own comments and suggestions for improvement. Students who serve as TAs also benefit from letters of recommendation that department faculty can then write on their behalf. This is particularly helpful for students who desire to pursue teaching as a career.

All data resulting from these surveys is archived by the department chair and stored in a file cabinet in his office, available for review.

**DEPARTMENT GOAL #2 - LABORATORY INSTRUCTION AND THE WRITING OF SCIENTIFIC ABSTRACTS**

**Program Goal** – Students will develop and improve skills in scientific writing. Specifically, our focus is on the writing of scientific abstracts, which summarize their experimental work in the laboratory. The goal is that by the end of the laboratory course, students become better able to articulate in clear, scientific terms the purpose of their work, the details of their particular investigation and analysis, and the conclusions they reach, and that quality of their written work be representative of that found in published scientific journals.

This goal addresses both program specific and institutional learning standards. Scientific writing style forms a sub-category general writing. Mastery of it is vitally important to students’ future careers in science. In developing the skill of summarizing their work in scientifically concrete and precise terms, students improve their general writing skills, and in the process assemble a more substantive and meaningful understanding of their scientific work.

By providing each student with specific feedback on their individual abstract writing skills, as well as by providing exercises and activities directed toward improved writing (peer review, rewriting, etc.), we seek to ensure that students develop abstract writing skills in measurable ways.

Mechanisms for feedback to students consist primarily of 1) written feedback on graded abstracts, 2) class discussions of common errors and concerns, with suggested strategies for improvement; this discussion is often accompanied by informal handouts listing common issues for discussion (see Appendix C for examples), and 3) peer review of other classmates’ papers.

**Student Outcomes** – Measurable outcomes for this goal are the graded laboratory abstracts. Separate numerical scores are assigned to the abstract and to the remainder of
the student’s report. Scores reflect how well the student’s write-up accurately represent the work they conducted in lab, and the degree to which it conforms to well-established scientific writing practice. **Criteria for success** include improved numerical scores, as well as progress for each student in areas of specific weakness as reflected in individual written feedback. A **benchmark of progress** is that, students increase, on average, their numerical scores by 10 to 20 % (i.e. 1 to 2 grade points) over the course of the semester.

**Data** – Numerical scores in the grade sheet serve as an appropriate monitor of *quantitative* improvement for individual students. For monitoring progress in *qualitative* work, photocopies of all student lab abstracts are produced for several assignments throughout the semester, representing early-, mid- and late-semester assignments. Each graded student abstract is amply annotated by the instructor, and the most common issues occurring in the graded papers are assembled into a list for handout in class for discussion. The photocopies are maintained in a departmental file, currently located in the office of the department chair. At present the file contains laboratory assignments from the fall 2005 and spring 2006 semester General Physics laboratories, PHY-022 and PHY-024. We have met as a department to discuss these collected papers, considering issues such as current strengths and weakness of our approach to teaching scientific writing, as well strategies for improving.

**Interpretation of the Results** – As a result of meeting on at least two occasions to discuss and analyze this past year’s collection of student abstracts, we have some preliminary observations, indicating some preliminary success in meeting our goals, as well as pointing to future improvements of our approach to this task.

- In the course of the semester, students showed steady progress in the following areas:
  - in the description of their experimental setup and procedure
  - in learning to keep within the space and format constraints
  - in their ability to process and convey results from their experimental work
  - in their ability to conclude, with supporting evidence, whether or not the experiment was a success in achieving its purpose
  - in their use of proper grammar and spelling

- A few areas still needing improvement are
  - in the precision of their language – many still struggle with scientifically ambiguous descriptions
  - overall time spent crafting and editing the abstract
  - in their attempt to include more content than necessary, at the expense of concreteness and clarity
  - in avoiding repetition

Additionally, we note that students in Chemistry and the Life Science generally experience more difficulty in adapting to the abstract writing model used in physics, due to different practices and emphases presented in the laboratories of their majors. Students in physics and engineering/physics are typically first year, whereas students from chemistry and the life sciences are typically juniors or seniors, having had several lab
courses in their own disciplines. Therefore students start with a variety of experiences with scientific writing.

**Using the Results** – Using our current approach, based on our collective judgment, student skills in abstract writing do appear to improve substantially throughout the semester. While individualized written feedback and group discussions on common pitfalls form constructive means by which students learn from their mistakes and improve, there are additional areas where we would like to implement some additions or changes. For example, we’ve would like to

- share more examples from the professional literature –abstracts selected for their clarity and accessibility – and read together in class and critique them as a group
- provide more opportunities for peer review – introduce more opportunities for students to critique one another’s abstracts, possibly anonymously, in order that they can more objectively approach the topic from a critical viewpoint. We evaluate them on their ability to critique one another’s work. We have done this in the past, and found it to be helpful, but for some reason did not implement in this past year
- adopt a universal “template” for abstract writing that all laboratory instructors would follow, to bring greater uniformity and consistency to the task. See appendix B for an example of a template currently used by one instructor.
- adopt different but complementary goals for the fall and spring semesters:
  - in the fall, we will have students concentrate on completeness of their overall experimental description, i.e. purpose, experimental setup and procedure, data analysis, and conclusions, and
  - in the spring semester concentrate on refinement of scientific language in order to conform better to professional journal standards.
- rotate lab partners on a regular basis, and provide time at the end of the lab to work on abstracts in small groups

**Next Steps** – For the coming fall semester, our plan is to continue the practice of photocopying student abstracts to chart individual student progress. We will establish a department-wide template for the writing of a laboratory abstract, and work toward greater consistency in our presentation of this task to students, in order to minimize differences with which students would otherwise encounter from semester to semester. We will use more opportunities for peer review and group participation as outlined above.

**DEPARTMENT GOAL #3 – STUDENT RESEARCH AND PRACTICA**

**Program Goals** - In the physics department we have a long history of providing students opportunities to conduct research with faculty. Each of the three department faculty members have held National Science Foundation grants (as well as others) with which to employ students in research. Students have had opportunity to conduct 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. No students in our department participated in external practica this past year, and we are therefore delaying a study of this experience until the following year.

Our basic goal in providing students research and practica opportunities in physics and/or engineering is that they become better equipped for success in graduate school or career. Research outside of the classroom is essential in today’s world of higher education in preparing students to compete favorably in graduate school and career. For the purposes of this report, emphasis will be placed on departmental research rather than on external practica. We will include a detailed study of practica for the engineering-oriented students during this coming year.

**Student Outcomes** – Albert Einstein has said

> “Everything that can be counted does not necessarily count; everything that counts cannot necessarily be counted”

We recognize that success in student research is “measurable” in several ways, but perhaps not as quantifiably as the other two goals we’ve discussed above. In this section, we would like to list some measures of success that we have accumulated, and suggest ways we would like to use these indicators in improving our program. These measures include

- Number of graduates who have participated in departmental research pursuing advanced degrees after graduating from Westmont
- The reputation of the institutions to which they are admitted
- Awards and honors they receive
- Grants acquired by the college, and the reputation of the granting agencies
- Student names on peer-reviewed publications
- Student presentations of research at national conferences

**Data** – The physics department graduates approximately 8 to 12 students per year, majoring in one of three possible degrees, the 4-year B.S. in Engineering/Physics, the 3/2 dual degree in Engineering and Engineering/Physics (for which Westmont awards the EP degree and another university awards the E degree), and the B.S. in Physics. During the past 9 years,

- **Graduates:** A total of 17 students have graduated having had the opportunity to conduct physics research with faculty (10 of them earning the BS in physics degree, instituted in 2000, and 7 earning the BS in engineering/physics degree);
• **Advanced Degrees:** Of these, 10 have gone on to pursue advanced degrees in physics or engineering (8 in physics PhD programs, and 2 in engineering Masters programs);

• Thus, the rate of those who have conducted research and gone on to pursue advanced degrees is 59%, a very positive indicator for our department, compared with other similar institutions (generally 50% is deemed high for the fraction of students that go on to advanced degree programs)

• **Schools for Advanced Study:** The schools to which these students have been admitted are likewise indicative of our program quality, and include Stanford, University of Chicago, Michigan State University, Cambridge University (UK), California Institute of Technology, and University of California at Berkeley.

The statistics relayed above form a strong indicator for the quality of our program. We are in the process of collecting statistics from the American Institute of Physics to back this assertion. In addition to these indicators, the following are worth noting.

• **National Conference Presentations:** Of the 17 students who have participated in research with faculty, 8 have presented their work at national meetings of the Division of Nuclear Physics of the American Physical Society. They each applied for and were awarded travel grants to the conferences, including full funding for housing at the conference site. These awards are quite competitive, and only between 40 to 60% of undergraduate attendees receive these travel grants. Hence the 100% funding record is indicative of the quality of research our students are conducting in the judgment of the conference application review committees.

• **Student Authorship:** Several of the above mentioned student names appear on professional, peer-reviewed journal articles published by department faculty.

• **Student Honors:** Two of the PhD students received graduate fellowships (an honor bestowed on a small percentage of entering graduate students in physics

• **Dissertation Award Nominee:** One has been nominated for a dissertation prize in the Division of Nuclear Physics of the American Physical Society. The award has not, at the writing of this report, yet been announced.

Additional external data supportive of the quality of our program include the following:

• **External Grants:** A total of at least 7 three-year NSF “Research at Undergraduate Institutions” (RUI) grants have been awarded to department faculty members. These are highly competitive degrees and are awarded on the basis of quality of the research experience received by the undergraduate students as judged by the NSF review panel of peers.

• The department also received a large equipment grant from the National Science Foundation to construct a portion of a large area neutron detector which is installed and in operation at Michigan State University.

• **Observatory Upgrade:** The College (through a proposal drafted by members of the physics department) was recently awarded grants from the W.M. Keck Foundation ($300,000) and the Stamps Foundation ($98,000) to replace our aging 16” observatory telescope with a state-of-the-art 24” telescope usable for cutting-
edge research purposes. W.M. Keck grants don’t come to “easily” to small academic institutions, and we therefore infer their agreed sponsorship of our upgrade to be a strong affirmation of the program quality we can offer to our students.

- **APS Fellowship:** One of the department members was recently inducted as a fellow of the American Physical Society for his work over the past 8 years in organizing national undergraduate conferences in nuclear physics, called the “Conference Experience for Undergraduates (CEU).” The conference travel and lodging grants for the undergraduate participants are funded by the National Science Foundation and the Department of Energy.

All of the data presented here is available for review, and are located in the physics department. The chair maintains a database of this information on his computer, as well as in a file in his office.

**Interpretation of the Results** – These data, though largely non-quantitative, are nonetheless strong indicators of our program’s success in preparing students for future careers in physics and engineering. We are encouraged by the growing body of data supporting the importance of this extra-curricular component of our students’ education.

**Using the Results** – We will continue to seek to offer first-rate research opportunities for our students. With the award of the Keck and Stamps grants, we are in an excellent position to build a new program in astronomical research.

**Next Steps** – Over the next year we plan to work with Office of Institutional Research to administer a questionnaire to students who have conducted research in our department and have moved onward into advanced studies or career. This questionnaire will help us better understand, from the opinions of those who have gone through the program, its weaknesses and strengths in order to offer a better more effective program to future participants.

**EXTERNAL DEPARTMENTAL REVIEW – SPRING 2007**

Our department is currently in the midst of planning an external departmental review to occur in Spring 2007. Individuals to form the review team, We anticipate that this review, which will be comprehensive, will help, among other things, facilitate progress in the areas we have identified.

**CLOSING REMARKS**

As stated in each of the three main sections of this report, all data referred to is stored in the physics department either in the file cabinet of the department chair, or in an electronic database in his computer.
APPENDIX A – DEPARTMENTAL TEACHING ASSISTANT SURVEY

Physics Department TA Survey

The following survey is for students who took a physics department class in fall 2005 or spring 2006, for which a teaching assistant (TA) was assigned.

The major objective of this survey is to aid in improving the teaching effectiveness of our TAs. Your responses will provide valuable feedback to us in the development of our TA training program. Your responses to the questions are very important, so please respond honestly and fairly. Consider the semester as a whole and try not to focus on isolated incidents.

The survey is anonymous, the website is located on a secure server and there is no risk assumed for participation.
If you have any questions or concerns you may contact Dr. Warren Rogers. Thank you for your input!!

<table>
<thead>
<tr>
<th>1) My current year in school:</th>
<th>First Year</th>
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<tbody>
<tr>
<td>2) The course I took was:</td>
<td>Pick one</td>
</tr>
<tr>
<td>3) The teaching assistant assigned to this course was knowledgeable in the course subject matter</td>
<td>Pick one</td>
</tr>
<tr>
<td>4) The teaching assistant seemed interested in the subject matter</td>
<td>Pick one</td>
</tr>
<tr>
<td>5) The teaching assistant explained the material clearly</td>
<td>Pick one</td>
</tr>
<tr>
<td>6) The teaching assistant was kind and respectful of me</td>
<td>Pick one</td>
</tr>
<tr>
<td>7) The teaching assistant was patient with my questions</td>
<td>Strongly disagree</td>
</tr>
<tr>
<td>8) The teaching assistant showed up regularly for help sessions</td>
<td>Pick one</td>
</tr>
<tr>
<td>9) The teaching assistant</td>
<td>Pick one</td>
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</tbody>
</table>
was on time for help sessions
10) The teaching assistant found useful ways of explaining the material in clear fashion
11) The teaching assistant mostly just showed us how to do the homework problems
12) The teaching assistant was well prepared for help sessions
13) I would recommend this TA to other students:

General comments about your experience with the class TA

The BEST part of the TA experience was

The WORST part of the TA experience was

What recommendations would you make to improve our TA program?
## Numerical Results from TA Survey – Spring 2006

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Knowledgeable</th>
<th>Interested</th>
<th>Explain Clearly</th>
<th>Kind</th>
<th>Patient</th>
<th>Showed Up</th>
<th>On Time</th>
<th>Helpful Clear</th>
<th>Did Homework</th>
<th>Prepared</th>
<th>Recommend</th>
<th>TA</th>
<th>Average Score</th>
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</table>

**Course Key:**

- PHY-011 – Physics for Life Sciences I
- PHY-013 – Physics for Life Sciences II
- PHS-017 – Physics of Music
- PHY-021 – General Physics I
- PHY-023 – General Physics II
- PHY-025 – Modern Physics
- PHY-040 – Differential Equations
- PHY-151 – Electromagnetic Waves and Optics
APPENDIX B – LABORATORY REPORT GUIDELINES

Westmont College

FULL LABORATORY REPORTS - GUIDELINES

Title page: should contain the following information:

a) Title of the experiment
b) Abstract should appear below the title (see below)
c) In the upper right corner put your name and the date you performed the experiment
d) In the lower right corner put the name(s) of the colleague(s) with whom you worked on the experiment.

Abstract: The abstract should form a concise summary of the experiment performed, with a brief mention of results and conclusions. You should address it to an audience with a scientific background, though not necessarily familiar with the particular experiment you are reporting. The abstract should provide the reader with a brief, informative overview of your experiment and results. Any further experimental detail desired by the reader could then be found inside the report. The abstract should include the following (the numbers of sentences are included only as a rough guide):

- Statement of purpose (1 or 2 sentences)
- Brief experiment description - equipment, setup, procedure, etc. (2 or 3 sentences)
- Analysis - how was your data analyzed, plotted, etc. (2 or 3 sentences)
- Results - final values with errors (1 or 2 sentences)
- Conclusion - successful? consistent within errors? etc. (1 sentence)

The general emphasis on the various sections listed above will vary of necessity from experiment to experiment. Note that the abstract should contain no figures or equations, which can easily be included inside the report. The abstract is to be double spaced, and should not exceed ¾ page typed. Use proper English, speak concretely, avoid ambiguity, and make it basically self-contained. It is a good practice to work through a few drafts, and have a friend read it for comments. Proof-read your work before handing in.

Formal report: Should include, with some flexibility, and not limited to, the following:

- Title page with abstract (layout described above)
- A summary of relevant calculations, errors, etc.
- Graphs of results and a printout of the spreadsheet, if relevant
- Any extra discussion, if needed, to supplement the abstract
- Conclusions
- Answers to any questions listed in the lab manual
APPENDIX C – SAMPLE ABSTRACT ADVICE HANDBOUTS

Feedback on Projectile motion lab abstracts

Abstract needs to be concise
Use double space!
Pay extra attention to your use of grammar
Use consistent tense
Don’t include equations in abstract
Proofread your work to catch obvious problems
Avoid wordy or clumsy sentences – revise until it speaks concretely and unambiguously
Use one continuous paragraph – don’t divide into sections
Be clear in your results/conclusions what it is you are comparing, and a statement about how good the agreement is.
Make sure your work is solely your own – that you don’t “borrow” from others, or let them borrow from you!!!

Feedback on Rotational Inertia lab

Avoid long sentences that try and say too much
Don’t use abstract terms you don’t previously define, such as “theta”
Never use “human error” as an explanation
Realize that all measurements have uncertainty, and you are to decide if the results are reasonable compared to your sense of the system’s overall precision
If your errors are much larger than expected, or if a number of results are always “larger” than the theoretical, then suggest some possible sources
Remember the difference between random errors and systematic errors
Know the difference between measurement and calculation
Avoid using “then” if possible
Avoid “the computer plotted” or “the computer calculated” – the computer is a tool that YOU use! You plotted, you calculated, etc.
Don’t mention Data Studio (or proprietary products in general)
Don’t refer to “given” or “designated” equations
Avoid the phrase “plugged it into an equation” at all costs!