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ABSTRACT

In six parts, this research panel report focuses on numerous aspects of an institutionally-supported project in Writing and Problem Solving across Disciplines conducted by four teachers at Central Oregon Community College in Bend, Oregon. The report's first section, "Introduction," is descriptive and gives some background on the research project. The report's second section, "Final Report," describes project activities completed, outlines project research questions, and summarizes findings. In the third section, 10 recommendations based on project findings are discussed. The fourth section presents materials from a presentation, including excerpts from "Professional Standards for Teaching Mathematics" and from "Everybody Counts," and a list of common faculty questions and responses. This section offers 12 writing and group learning assignments used effectively in Contemporary Mathematics for liberal arts students and Calculus courses at the college. The fifth section presents physics lab writing assignments, with a schema for their evaluation, used in a college physics sequence, and includes sample assignments and course materials. The report's final section presents course descriptions. (SR)

Writing and Learning Across Disciplinary Boundaries in College Math and Science Courses:

Research Strand Panel at the November 1994 NCTE Convention
Orlando, Florida

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Introduction

Cora Agatucci, the Writing Across Disciplines Program Director at our community college, will describe program goals and methods and relevant findings of an institutionally-supported research project in Writing and Problem Solving across Disciplines conducted by session speakers. In a recent issue of *College Composition and Communication*, Robert Jones and Joseph J. Comprone offered a cogent response to their title question: "Where Do We Go Next in Writing across the Curriculum?" (Feb. 1993). In particular, they call for more effective "interactive faculty dialogue" (67) among Writing and non-Writing faculty, particularly in science and technology, as the basis for developing "consistent rhetorical approaches to writing in different disciplines," an area in which research has only just begun (62). While our Writing across Disciplines Program is only two years old, starting decades behind the WAC movement nation wide, a gifted faculty committed to student-centered innovations in teaching and learning, and to genuine cross-disciplinary collaboration have enabled us to sidestep some of the WAC program pitfalls outlined by Jones and Comprone, Bazerman, McLeod and other WAC specialists since 1988.

In consequence, we believe significant progress is already being made in developing effective writing and problem solving assignments across the curriculum, even in the most traditionally resistant disciplines of math and science. Here the "banking" model of education described by Freire has long obtained, and most WAC advocates have made only slow and limited incursions. Writing faculty can do little without the cooperation and collaboration of disciplinary insiders. Fortunately, math and science department instructors at our community college have been responsive to the challenges and ready to work collaboratively across disciplines to move past barriers. Central to the effort has been an honest appraisal of the barriers in open cross-disciplinary discussions. The willingness of COCC faculty to share responsibility for the development of students' thinking, reading, writing, speaking, and problem-solving skills across the curriculum--perhaps the greatest resource of many community colleges--has prompted widespread acceptance of the value of writing to learn mathematics and solve problems in courses ranging from Developmental Math to Calculus and Physics. Now, in November 1994, the time of the NCTE National Convention, the findings of our research project in Writing and Problem Solving across Disciplines are ready for presentation, and we will integrate insights gained from the research project into our discussions of writing and learning in math and science courses.

To offer our convention panel audience some practical models for integrating writing into math and science courses, Jack McCown and Mike Sequeira will present writing and group learning assignments used effectively in Contemporary Mathematics for liberal arts students and Calculus courses at COCC; and Bruce Emerson will present physics lab writing assignments, with a schema for their evaluation, used in his college physics sequence. Sample assignments and course materials are included in this packet. We welcome your responses. We encourage you to ask questions and offer suggestions at the end our presentation, and we invite you to continue the dialogue after the convention closes by contacting us at the addresses given above.

Background on Research Project

Since 1991, Writing and Math instructors at our community college have collaborated in developing effective writing assignments for mathematics courses and for an innovative new mathematics textbook (for Math 105), focusing on college-level problem solving, designed for liberal arts students. Such collaboration across the curriculum was expanded, and efforts to improve writing instruction and group learning techniques campus wide were diversified during 1992-93 when the in-house Program for Excellence in Teaching at COCC funded a Formative Evaluation Program. Writing across Disciplines consultants have benefited by learning more about their non-English colleagues' instructional emphases and goals, by increasing their effectiveness in helping students transfer writing and problem solving skills across courses, and by improving support services like the campus Writing and Math Labs. Beginning in 1992, the four presenters for this panel have regularly conducted or participated in Writing across Disciplines workshops on designing and evaluating writing assignments in math and science courses. Further, three of the speakers (Agatucci, McCown, and Sequeira), instructors of Writing and Mathematics, began a limited research project in their Winter-Spring 1993 classes to assess student attitudes toward writing to learn and solve problems. As part of our preparation, we have reviewed literature in the fields of writing and problem solving across the curriculum. This research project has fed a growing interest in collaborative teaching and in learning outcomes assessment as means to enhance curricular development and program planning. The speakers were awarded COCC Program for Excellence in Teaching support to expand their research project in 1993-94. Research activities completed as part of that project are described in the Final Report to the Central Oregon Community College Program for Excellence in Teaching. Also included in this packet you will find the "Project Research Questions and Summary of Findings" and ten "Recommendations" made based on those findings.

Final Report
&
Recommendations
Writing & Problem–Solving Across Disciplines
Research Project

CENTRAL OREGON COMMUNITY COLLEGE
Program for Excellence in Teaching

FINAL REPORT: 1993-94 Research Project
WRITING & PROBLEM-SOLVING ACROSS DISCIPLINES

Submitted by Cora Agatucci, Jack McCown, & Mike Sequeira

PROJECT ACTIVITIES COMPLETED:

1. English 104 Group Interview, conducted by McCown & Sequeira, Fall 1993: 33 students participating (summary report available upon request).
2. Math 105 Group Interview, conducted by Agatucci, Fall 1993: 15 students participating (summary report available upon request).
3. Math 251 Group Interview, conducted by Agatucci, Fall 1993: 15 students participating (summary report available upon request).
4. Writing 122 Group Interview, conducted by McCown & Sequeira, Fall 1993: 9 students participating (summary report available upon request).
5. Surveys conducted in Fall 1993 in 6 sections of Writing 121, 2 sections of Math 105, 1 section of English 104, English 201, and Writing 122 to identify up to 50 student participants for projected Winter-Spring 1994 interviews and portfolio collection. Thirty-five students representing diverse majors and programs were invited to participate in the PET research project; 23 of these accepted the invitation and completed interviews and portfolio collection activities in Winter-Spring 1994. All signed consent forms enabling project faculty to share their words and work, and requested that they receive copies of any reports or papers that may result from this PET research project.
6. Twenty-three students engaged in an individual interview with one of the three project faculty during Winter term 1994 and compiled a portfolio of syllabi and sample writing assignments from Fall 1993 and Winter 1994 term courses. Selected student work was duplicated and portfolios were returned to students at the end of Spring 1994 term. (Interview transcripts and copies of student work available upon request.)
   NOTE: These students do not necessarily identify themselves as "good writers"; however, almost all are "A" or "B" students, judging from grade reports submitted for Fall 1993 and Winter 1994 courses completed. Another common denominator: these students agreed to participate in the project because they take education and learning seriously, appreciate such a research effort by instructors to collaborate and thereby improve the quality of instruction, and are interested in discussing their own and others' learning and teaching processes.
7. Ten of the 23 student research participants met with project faculty for a group interview at the end of Spring 1994 term to discuss research findings (Summary of group interview available upon request).
8. McCown and Sequeira prepared curriculum and team-taught one section of Math 105 in Spring 1994. Agatucci observed four meetings of this class. (Summary report on Agatucci's observations and course student evaluations available upon request).
9. McCown and Sequeira prepared and made guest presentation on gender issues in mathematics for Agatucci's Women's Studies 101 course in Spring 1994. Instructional issues relevant to this PET project were explored with students during two class discussions, with 42 students participating, and in student dialogue journal entries. (Summary of class discussion and course student evaluations available upon request.)
10. Drawing upon this research project in progress, Agatucci prepared panel/workshop proposal on "Writing and Learning Across Disciplinary Boundaries in College Math and Science Courses," with the collaboration of co-presenters McCown, Sequeira, and Bruce Emerson, for the 1994 Annual Convention of National Council of Teachers of English in Orlando, FL. Proposal was accepted, through juried selection, in panel format for inclusion in the November 1994 national convention program as part of the NCTE Research Strand. (A copy of the accepted NCTE Proposal is available upon request.)

RESEARCH PROJECT FINDINGS

The primary aim of this PET research project was investigate student responses to the research questions stated below. The following summary of our findings has been culled our analysis of the contributions of more than 75 students who participated in some form in our research project during 1993-94.

Project Research Questions & Summary of Findings

1. How much writing are COCC students actually doing across the disciplines?

All students reported doing some form of formal or informal writing in at least one of their classes each term. It is beyond the scope of our project to state more than general tendencies regarding how much and what kind of writing COCC students are being assigned. However, we can observe that students report most writing is being assigned in courses offered through the Humanities and Social Sciences Departments, especially writing, literature, history, and psychology classes. Most students report that the least writing - often little or no writing - is being assigned in courses offered through the Science Department and Professional-Technical programs.

Most students believe that writing could be integrated productively into any class, regardless of discipline, though they expressed distress at the implications for trying to balance both student and teacher workloads if all courses were writing intensive. There was a sense that writing in other classes could help them to learn the subject better, especially if they had to explain to their teachers what they understood. A vocal minority recommended that (more) writing should be required in science courses; also mentioned were selected social science, business, literature, professional-technical and engineering courses. In some cases, these latter recommendations came from students who had experienced difficulty mastering course concepts in writing-less courses.

Those students being assigned writing in Mathematics classes reported that they had not expected this requirement in a math class, though almost all felt the writing assignments had been beneficial in meeting course learning goals; and most had never been required to write in a math class before. Typically, students who entered a math class with positive attitudes toward writing and its value to the learning process tended to view the math writing assignments with favor and welcome the departure from traditional math instructional frameworks; those with negative attitudes were likely to view the math writing assignments with resistance.

2. Do students believe writing helps them learn in other disciplines? What types of writing are assigned, and to achieve what goals, in non-Writing classes?

Students generally agree that writing across disciplines is helpful, especially writing to learn course content and writing to develop skill. However, the types of writing and amount of writing that are most effective vary from course to course and from discipline to discipline.

Students report being assigned a wide range of writing types, from lab reports to term papers, from in-class essay exams to reading response journals. Students acknowledge that "essays" and "paragraphs" are common genres or recognizable components of these writing assignments, but understand that some of their teachers create particular writing genres to suit the course or learning goals in question.

Many students rely heavily upon non-assigned writing-to-learn activities, such as outlining lectures, keeping reading journals, or taking notes on study group sessions. As one student explained: "Studying by writing helps me to figure out why something works. It helps me to remember better when I can verbalize what is going on and explain a process to myself. You always personalize responses when you have to write, so it makes it easier to remember things when I write them out when I'm studying." Other students testified regarding how they use writing for themselves in courses that do not require writing. For example, in one such science class, students were provided with a study guide for exams that contained key words and concepts, sans descriptions and explanations. The student noted that if she took the time to fill in the gaps of the guide (i.e., the equivalent of several short answer essays), she would almost always do better on the tests, because she retained more of the information.

Students perceived many learning and teaching goals being met through these writing assignments. For example, students believe that they are being asked to write in a mathematics class to stimulate thinking, to teach themselves the mathematics concepts, and to show the instructor what they know and how well they are mastering the math concepts being taught. Some also said that writing helped them teach the math to peers, but many seemed not to recognize that they were using writing in this way within the context of the class. When students stated that they would like to see more emphasis on writing in a particular course, an oft-cited reason is that if students had a writing assignment on a difficult concept to be tested later on an exam, writing about the concept significantly improves their mastery of that concept and helps them do better on the ensuing exam. While some acknowledged that it is very difficult to put math symbology into words, most agreed that the effort is worth it; in particular, students discovered what they did and did not know from the writing process. Most students also agreed that writing helps in other ways as well: learning and practicing to improve written communication was almost universally recognized as a necessary skill in life, not just in college classes. Older students seem more predisposed to argue for the importance of knowing how to write and the value of effective communication skills to career and professional advancement.

Students enrolled in literature courses that require writing cited similar reasons. They believe that they can learn more about the subject if they can write about it, because they can't convey what they understand without writing about it. Writing in a literature class helps students discover and crystallize their ideas about what they've read to themselves and others. Writing about their ideas prompts students to think longer and more deeply about those ideas, to take a second look at what they've read and to reconsider how literary concepts taught in class may apply. This is necessary since students not only need to clarify ideas for themselves but to generate the quality of thinking required to convince the instructor that they have understood the literary works. The type of writing assigned requires that students have opinions and be able to back them up with convincing argument, evidence from the literary works, and explanation. Students believe timed essay tests help them learn to "think on our feet" and demonstrate to the instructor how well prepared they are and how well they understand course content.

Students recognize that different learning and teaching styles exist in themselves and in their teachers, and they appreciate course designs which offer them multiple and frequent modes of demonstrating what they have learned, giving them opportunities to play to their strengths as well as to strengthen their weaknesses.

Students recognize that integrating new pedagogical strategies into a course - like writing assignments or group discovery projects in a math or science course - may mean that fewer concepts and less material can be covered in that course. The sacrifice may be worth it, however, if students learn the material that is covered better and retain it longer. And, of course, this advantage must be carefully weighed against other factors, such as whether the students will still be adequately prepared for the next higher level course.

3. Do students seem to transfer the writing skills they learn in writing classes to non-Writing classes where writing is assigned? If so, how successfully? What can instructors do to help students make this crucial transfer?

The majority of students answer yes, they are transferring some key writing skills they believe they've learned in writing classes to non-Writing classes whe writing is assigned. A minority of the PET project student interviewees stated that they are not consciously aware of such transfer of skills. The types of writing skills students cited as successfully transferring to non-Writing courses vary. However, most students agree that the most readily transferable writing skill/genre is the college essay. Students agreed that adjustments have to be made when writing for different disciplines, and a key success strategy is figuring out what a specific teacher wants from a given writing assignment. Yet students frequently find they are successful when they apply the composing and thinking processes, organizational skills, and standard written English proficiency which they have developed in past writing courses. Students seem to affirm that, to some extent at least, a right formula for writing and a college level of competent writing do exist.

Writing 122 students believe that the kind of writing students do in this class transfers to the writing in other classes largely without students having to think about it. The mechanics used in writing classes become second nature, so students use the same approach in other classes out of habit. The writing in Writing 122 is definitely carried over to other classes where these students have to write, including math and social sciences. No one in this class was writing in their science courses. These Writing 122 students believe that what carries over to other classes is how to organize their thinking so that they can state their positions. Analysis, organization, logic, working with other people (work in groups) are what students said they use most from this class in other classes. These Writing 122 students believed this course taught more useful transferable skills than did Writing 121: Writing 122 focused on critical evaluation, analyzing and writing about issues and arguments, summarizing, expressing opinions, accepting others' opinions and justifying one's own, whereas in Wr 121 most felt they had just learned grammar, sentences, and punctuation. However, other students noted the timed essay exam writing and critical analysis in Writing 121 transfers well to other courses. Many students also observed that they learned effective composing processes and organizational approaches in their introductory English Composition courses.

Math 105 students cited the following skills as successfully transferred: organization, formatting, a process for accomplishing writing, grammar/sentence structure/mechanics, the ability to write clear explanations in a step-by-step way. Students agreed that their math instructors are not as exacting regarding the necessity of having a thesis or command of standard written English as their English teachers are. All 15 Math 251 students present for the group interview had taken writing classes previously, all but three at COCC. They agreed that they used in Math 251 the following skills learned in those writing classes: the conventions of standard written English (grammar, usage, mechanics, punctuation), organization, coherence, structures for organized thought.

A key factor that affects how well students are able to transfer their writing skills (assuming these skills are already at college-level) from writing courses to non-writing courses, is how well instructors are able to articulate their expectations and grading criteria, as well as discipline-specific goals and modes of writing. Students believe that teachers in non-writing courses can most effectively deal with the problem of competent writing students trying to get away with poor writing by articulating higher standards for acceptable writing in that course. Math 251 students also stressed the importance of being allotted enough time to complete a given writing assignment.

4. How do instructor expectations and grading standards for student writing vary from discipline to discipline? Do common evaluation criteria and emphases emerge across some disciplines?

Almost all students stated that instructor expectations and grading standards for student writing *do* vary - not only from discipline to discipline but even from instructor to instructor within the Writing program. Many students expressed at least some degree of frustration with this variance, and a few testified that they choose not to use the Writing Lab because they cannot be assured that the advice one Writing instructor offers them will win a good grade on the assignment from a different instructor. Most acknowledged, however, that given the wide range of types of writing and the differences in the learning goals they are designed to serve, as well as individual differences among the teaching styles of instructors and the learning styles of students. it is not unreasonable to expect students to learn to adapt themselves to these differences just as it is crucial to develop skill in "figuring out what the teacher wants." It is easy to understand why students value so highly the instructor who goes through the directions and expectations, especially with examples, for the first [writing] assignment very carefully and clearly to give students a good feel for what the teacher wants. Furthermore, students believe strongly in the importance of teachers talking to each other and collaborating among themselves on writing skill expectations within and across disciplines. Once teachers better understand the differences and similarities in their colleagues' writing skill expectations and grading criteria, they will be much better prepared to communicate those expectations and criteria to their students.

Students made the following observations about the differences they perceive among writing assignments in different disciplines:

1. Writing for math, sciences, and technological programs is very structured without much room for creativity. Technical report or lab report writing is often required, and lecture/reading notetaking and outlining the most common form of non-assigned/informal writing. Shorter instructor-designed process analysis and definition writing is common in math classes. Business and criminal justice classes may require short written responses to text questions, case-studies and research-based term papers. More attention is generally given to content, to being able to show what the student knows, than to form.

2. Writing for humanities and some social sciences courses is perceived as more "free form," less structured, entailing "lots of tossing around of ideas and personal opinions," the issue being less coming up with the right answer than being able to explain and support opinion. Essays are often required, both in-class and out of class, as well as research-based term papers. Informal writing assignments like reading response writings and journals, with accompanying freedom of expression and less concern for grammatical correctness, are more common in these courses.

Writing classes give more attention to formal features and grammatical correctness than any other type of class, and predictably writing teachers tend to take student writing much more seriously than do non-Writing teachers. Speech and Writing adhere most strictly to the idea of organizing a presentation to stick to a thesis and topic than other disciplines. Several students noted that teachers in other disciplines do not hold them to the same rigorous standards of writing as their composition instructors do, and students respond by lowering their performance standards.

Students note the necessity of making the following adjustments in their writing for different disciplines:

1. Audience and Level of Detailed Explanation. Many students cited the importance of knowing what kind of audience they were writing to for a particular assignment, and complained that many non-Writing teachers do not make this expectation clear. One student observed that he initially made the mistake of writing for his literature teacher the same way that he did for his math and science teachers. In this case because the lit teacher wanted the student to assume a specialized expert reader and to reduce the amount of basic explanation provided, the math and science instructors required that the writing be geared toward a generalized uninformed reader who would require much more detailed and basic development of the student's ideas. Another student noted he might write freely and emotively for himself for his Spanish course, while in geography he must write more formally solely for the instructor.

2. Style, Tone and Diction. Most students noted the value of developing flexibility and range in writing styles for success across disciplines. Social science instructors may encourage a scientific, non-emotional, impersonal tone and attitude toward the material, limiting or disguising expression of opinion, judgment, or feelings; whereas Writing instructors encourage evaluation, opinion, rhetorical technique, and mechanical correctness.

3. Documentation Systems. To some students it seems that every teacher requiring research-based writing requires that students use a different format for documentation, and this variance is often the source of frustration.

5. How do instructors evaluate writing? What assessment methods & types of comments do they offer their students? What do students do with these comments?

Students report differences in the ways instructors evaluate writing, ranging from detailed critique to checks for work completion. Students recognize that different modes of feedback and assessment are appropriate for different types of writing assignments designed to achieve different pedagogical ends, and students are more likely to accede to the appropriateness of instructors' schema if instructors take the time to explain their rationales and expectations. For example, math students might complain about having to explain "everything" to a generic "uninformed reader," even basic math concepts or problem solving steps that they tend to take for granted at the Math 251 level. Students noted getting "docked" by the instructor if they neglected to address basic concepts or steps in these writing assignments. However, a few very articulate students seem to understand very well why they thought they should be writing for this reader: for example, the first project for the business person who doesn't understand [advanced] math concepts is a "very realistic" audience to write for. They recognized this project as a "real world situation" that they might well encounter and hence the writing practice is crucially important.

Students are very aware of their own time limitations and most are quite ready to concede that instructors suffer from the same constraints that necessarily curtail the number of writing assignments and the amount of feedback they can offer students. Most students acknowledged that they prefer to receive detailed written commentary from their instructors and that they do review this commentary carefully. They want substantive (e.g. logic, clarity, quality of ideas, relevance of assumptions) as well as formal (mechanics, punctuation) critique of their work, positive and negative commentary. Students appreciate the opportunity to revise a critiqued assignment or to use commentary to exercise developing skills in a sequential writing assignment or another course. Some noted frustration if they have no chance to revise or apply what they have learned from such commentary, and were slow to acknowledge the fact of skills transfer to future courses and to delayed opportunities to use what they had learned. Students often perceive criticism as being "ripped" by their instructors, and they are most likely to resent being given no commentary or only negative commentary - with or without bad grades - if the instructor offers no positive feedback or constructive suggestions for improvement. Students have mixed reactions about peer evaluation and about group methods of responding to writing, such as examples placed on reserve in the library or writing workshops in class.

Several students complained about course assessment based entirely on one midterm and one final exam or limited numbers of other heavily weighted projects, primarily because they were unsure how well they were doing in the class and did not find out they were in trouble until it seemed too late to correct misunderstandings and make up poor grades. Many students complimented teachers who offer multiple and early opportunities for students to earn feedback on their performance and standing in a class, some noting that more and shorter writing assignments in particular may be very effective in achieving the course's teaching and learning goals.

6. What do students believe they gain from their courses? What are their learning goals?

Generally, students seem to appreciate course goals, assignments, and activities which encourage true critical and creative thinking, authentic discovery on the part of students; instructors and disciplines that seem to require of students more than simple right or wrong answers, that allow for multiple legitimate responses and that validate students' ideas and solutions. Students appreciate real questions and debatable issues - rather than rhetorical or canned questions for which the teacher is seeking--and baiting students to come up with--one specific "right" answer. Students appreciate teachers who encourage or at least tolerate disagreement with the instructor's own answers and views.

Especially in courses where controversy and divergence of opinion is likely, students appreciate a learning environment in which a sense of trust has been created, a willingness to accept well-reasoned opinions that are different from the instructor's, opportunities for group discussions, and the sense that everyone should be involved in class discussions. They want more time to think about the difficult questions the instructor asks. Students advise that some instructors need to know that silence is OK. For example, if the instructor asks questions - hard questions, profound questions - that take a while to understand and think through - she should not move to an answer before students have had a chance to think some of the harder questions through and figure out what they want to say.

The following qualities in instructors and learning environments were listed as valued by students:

1. Safe, supportive learning environment; the objective, non-biased, non-threatening, and sensitive handling of differences of opinion.

2. Addressing not one but two sides of a question or multiple perspectives, and giving students the opportunity to weigh these and come to their own judgments.

3. In particular, WS 101 students commended particular guest presentations or other course materials for the following attributes:

-Well versed in subject matter
-Listen well to students' input & put it to use
-Creative, unusual approaches to subject matter, visual aids
-Handling of sensitive subjects, awareness of controversy, use of humor, honesty, intelligence
-Relevant to students' life experiences
-Challenging, thought-provoking
-Inclusion of personal narratives
-Group learning & team-teaching
-Puts info into coherent perspective
-Risk-taking, responsive to audience mood/interest, flexible
-New and important information
-Casual, conversational style
-Communication genuine caring attitude toward women's issues
-Use of more than one delivery or discussion method, variety
-Emotionally moving effect; made students want to act; convey personal conviction
-Practical, able to apply to own lives
-Communicate enthusiasm for subject, learning, and students
-Relevant to course goals & content
-Well organized, clear
-Very current, topical information
--Give students a chance to speak, narrate life stories; instructor is interrruptible

Writing & Problem–Solving Across Disciplines Recommendations

The following recommendations are offered for discussion to the campus community. They represent our suggestions for action based on the major findings of the research project, *Writing & Problem–Solving Across the Disciplines*, funded by the Program for Excellence in Teaching during the 1993–1994 school year. These recommendations are submitted by Cora Agatucci, Jack McCown, and Mike Sequeira.

1. *All COCC instructors should acquaint themselves with the potential value of integrating writing to learn assignments into their courses.*

   In areas that traditionally assign little or no writing, this would suggest a reevaluation of curricular goals and the pedagogies in use to achieve those goals to determine whether more informal or formal writing assignments could be integrated into the curriculum. Instructors should carefully weigh the learning advantages of writing cited by students in this study against perceived disadvantages such integration would pose such as increased workloads for students and instructors and the concern that fewer concepts and less material would be covered.

2. *Instructors wishing to integrate writing assignments into their courses should investigate different models used in different disciplines to determine the types and amount of writing that would be most effective for their courses.*

   The Faculty Development Program and Writing Across the Disciplines consultants should actively facilitate opportunities for cross–disciplinary exchange, including workshops and opportunities for team–teaching.

3. *Where common standards of writing performance do exist, they should be articulated. More dialogue and consensus building should take place both within and across disciplines.*

   Once teachers better understand the differences and similarities in their colleagues' writing skill expectations and grading criteria, they will be much better prepared to communicate those expectations and criteria to their students. Writing lab practices, such as tutor's reports to instructors on advice given students in conference, will assist instructors in understanding the type of assistance students have received in lab conference and reduce the perceived discrepancies among different instructors' expectations and assessment criteria.

4. *Effective learning across disciplines can be strengthened if instructors explicitly encourage students to improve their learning skills and study techniques by utilizing non–graded writing–to–learn activities.*

   The lessons of successful students who employ such methods (e.g., outlining lecture notes, keeping reading journals, writing short essay responses to study–guide questions, or taking notes on group study sessions) can serve as a model for new or less successful students desiring to improve study skills and to develop effective learning habits.

5. *Instructors should consider ways to diversify their teaching strategies, implementing course designs which offer students multiple and frequent modes to demonstrate what they have learned and to receive timely, helpful feedback on their progress and performance in class.*

   Many COCC instructors employ collaborative learning strategies involving small student peer work and recognize their potential for enabling students to take an active role in their own education. Evidence suggests that workshops and cross–disciplinary exchanges on this subject would be helpful to instructors desiring to explore diverse strategies.

6. *Instructors need to acquaint themselves with the content and exit expectations of writing courses relevant to those skills they expect their students to demonstrate in their own courses. Instructors of skill development courses should work to acquaint themselves with the diverse applications of the skills they teach across disciplines and programs.*

   Students need direct and explicit assistance from all their instructors in transferring writing and other key skills necessary for college success across program and disciplinary boundaries.

7. *The Writing faculty is commended for initiating a project to define proficiencies and establish outcomes assessment in all writing courses. In the process, the Writing faculty should work cooperatively with non-Writing faculty, programs, and departments to strengthen the cross-disciplinary and workplace applications of the writing skills and processes taught at each stage in the Writing sequence in order to enhance students' ability to transfer their writing skills more effectively across the curriculum.*

Students expressed some ambivalence about the transfer and application of the writing skills and processes learned in Wr 121. Clearly, Writing and non-Writing instructors alike could do more to assist students in recognizing the value of Wr 121's concentration on developing skill in writing essays and on in–class timed writing, on developing effective composing and organizational skills across disciplinary boundaries. More students acknowledged the transferability of skills learned in Wr 122 to writing and thinking tasks assigned in other classes. The Writing faculty may wish to consider whether skills now emphasized in Wr 122-- i.e. critical evaluation; analysis of and writing about issues; summarizing, expressing, justifying opinions--could be integrated into the Writing sequence at an earlier stage.

8. *Instructors need to carefully articulate their performance expectations and grading criteria to students by giving clear directions and examples as well as clear discipline–specific expectations for writing.*

It is clear that there is a wide range in types of writing and in discipline–specific learning goals that writing assignments may be used to achieve. In addition, individual differences among the teaching styles of instructors and the learning styles of students imply that students need help from all instructors in the process of "figuring out what the teacher wants." Instructors need to guide students in making necessary adjustments in audience, level of detail in explanations, style, tone, diction, and documentation.

9. *Instructors should explain rationales for the types of writing assignments they give, the criteria by which they are graded, and the amount and types of feedback they choose to offer.*

Students appreciate substantive, as well as formal, critique of their work. Students desire positive commentary as well as constructive suggestions for improvement, and need more assistance than they now receive in learning to use criticism – especially negative criticism – constructively. Exhaustive commentary is not always necessary to be useful in the learning experience.

10. *The College should support an ongoing formative evaluation program to promote in-house faculty development opportunities, teaching innovations and increased classroom effectiveness through programs like Writing Across Disciplines.*

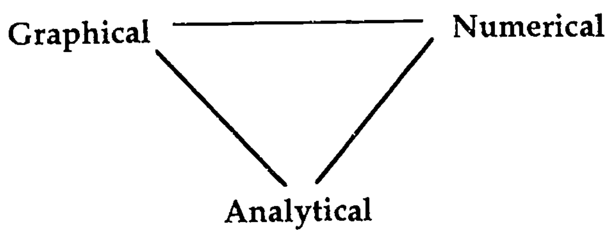
Such a program can effectively support the faculty in responding to Recommendations #1-9 above, and ensure continuation of the Writing Across Disciplines Program in the following efforts: (1) offering at least one introductory session annually; (2) designating consultants to work with individual departments on integrating appropriate writing assignments into their curricula; (3) coordinating several workshops each year to address topics of general interest, such as writing assignment design, in-class essay exam writing, evaluating student writing, collaborative writing and group learning strategies; (4) sponsoring innovative team teaching and classroom research projects.

Presentation: Jack McCown, Mike Sequeira
Mathematics Department
Central Oregon Community College

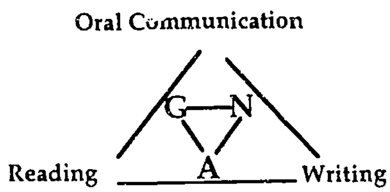
How we got ourselves into this:

- Meetings, Discussions with peers
- NCTM Standards (see attached excerpts)
- Everybody Counts (see attached excerpts)
- Writing Textbook, *Patterns in Mathematics*, PWS Kent, 1994
- National and local interest in Calculus reform
- Writing Across Disciplines (WAD) workshops on our campus
- Specialty sessions (creating writing assignments, types of assignments, grading practices, defining audiences)
- Involvement of writing faculty
  a. Having designated liaisons between writing faculty and departments
  b. Tailored workshops to discipline specific assignments and needs
  c. Role of writing teachers in encouraging involvement
    i. Not worried about outsiders stepping into discipline
    ii. Willing to act as mentors and guides
    iii. Keep discussions and suggestions at level of improving instruction/not a case of insisting that certain writing styles and grading practices be used.
    iv. Providing a non-threatening environment to peers of learning how to create writing-to-learn activities.
    v. Provide demonstrations, models, examples of successes and failures

Current model in mathematics



- Embed in larger model: Critical Thinking and Communicating



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Excerpts from

PROFESSIONAL STANDARDS FOR TEACHING MATHEMATICS

National Council of Teachers of Mathematics (NCTM)

and

EVERYBODY COUNTS:
A Report to the Nation
on the
Future of Mathematics Education

Mathematical Sciences Education Board
Board on Mathematical Sciences
Committee on the Mathematical Sciences in the Year 2000
National Research Council

Professional Standards for Teaching Mathematics

STANDARD 1:
WORTHWHILE MATHEMATICAL TASKS

The teacher of mathematics should pose tasks that are based on --

- sound and significant mathematics;
- knowledge of students' understandings, interests, and experiences;
- knowledge of the range of ways that diverse students learn mathematics;

and that

- engage students' intellect;
- develop students' mathematical understandings and skills;
- **stimulate students to make connections and develop a coherent framework for mathematical reasoning;**
- **call for problem formulation, problem solving, and mathematical reasoning;**
- **promote communication about mathematics;**
- represent mathematics as an ongoing human activity;
- display sensitivity to, and draw on, students' diverse background experiences and dispositions;
- promote the development of all students' dispositions to do mathematics.

STANDARD 2:
THE TEACHER'S ROLE IN DISCOURSE

The teacher of mathematics should orchestrate discourse by --

- posing questions and tasks that elicit, engage, and challenge each student's thinking;
- listening carefully to students' ideas;
- **asking students to clarify and justify their ideas orally and in writing;**
- deciding what to pursue in depth from among the ideas that students bring up during a discussion;
- deciding when and how to attach mathematical notation and language to students' ideas;
- deciding when to provide information, when to clarify an issue, when to model, when to lead, and when to let a student struggle with a difficulty;
- monitoring students' participation in discussion and deciding when and how to encourage each student to participate

STANDARD 3:
STUDENTS' ROLE IN DISCOURSE

The teacher of mathematics should promote classroom discourse in which students--

- listen to, respond to, and question the teacher and one another;
- **use a variety of tools to reason, make connections, solve problems, and communicate;**
- initiate problems and questions;
- **make conjectures and present solutions;**
- explore examples and counterexamples to investigate a conjecture;
- **try to convince themselves and one another of the validity of particular representations, solutions, conjectures, and answers;**
- rely on mathematical evidence and argument to determine validity.

STANDARD 4:
TOOLS FOR ENHANCING DISCOURSE

The teacher of mathematics, in order to enhance discourse, should encourage and accept the use of-

- computers, calculators, and other technology;
- concrete materials used as models;
- pictures, diagrams, tables, and graphs;
- invented and conventional terms and symbols;
- **metaphors, analogies, and stories;**
- **written hypotheses, explanations, and arguments;**
- **oral presentations and dramatizations.**

STANDARD 5:
LEARNING ENVIRONMENT

The teacher of mathematics should create a learning environment that fosters the development of each student's mathematical power by--

- providing and structuring the time necessary to explore sound mathematics and grapple with significant ideas and problems;
- using the ph ical space and materials in ways that facilitate students' learning of mathematics;
- providing a context that encourages the development of mathematical skill and proficiency;
- respecting and valuing students' ideas, ways of thinking, and mathematical dispositions;

and by consistently expecting and encouraging students to--

- work independently or collaboratively to make sense of mathematics;
- **take intellectual risks by raising questions and formulating conjectures;**
- **display a sense of mathematical competence by validating and supporting ideas with mathematical argument.**

STANDARD 6:
ANALYSIS OF TEACHING AND LEARNING

The teacher of mathematics should engage in ongoing analysis of teaching and learning by--

- observing, listening to, and gathering other information about students to assess what they are learning;
- **examining effects of the tasks, discourse, and learning environment on students' mathematical knowledge, skills, and dispositions;**

in order to--

- ensure that every student is learning sound and significant mathematics and is developing a positive disposition toward mathematics;
- challenge and extend students' ideas;
- adapt or change activities while teaching;
- make plans, both short- and long-range;
- **describe and comment on each student's learning to parents and administrators, as well as to the students themselves.**

EVERYBODY COUNTS
A Report to the Nation
on the
Future of Mathematics Education

Learning Mathematics

In reality, no one can *teach* mathematics. Effective teachers are those who can stimulate students to *learn* mathematics. Educational research offers compelling evidence that students learn mathematics well only when they *construct* their own mathematical understanding. To understand what they learn, they must enact for themselves verbs that permeate the mathematics curriculum: "examine," "represent," "transform," "solve," "apply," "prove," "communicate." This happens most readily when students work in groups, engage in discussion, make presentations, and in other ways take charge of their own learning. (p.58)

Engaging Students

No teaching can be effective if it does not respond to students' prior ideas. Teachers need to listen as much as they need to speak. They need to resist the temptation to control classroom ideas so that students can gain a sense of ownership over what they are learning. Doing this requires genuine give-and-take in the mathematics classroom, both among students and between students and teachers. The best way to develop effective logical thinking is to encourage open discussion and honest criticism of ideas. (p. 59)

When students explore mathematics on their own, they construct strategies that bear little resemblance to the canonical examples presented in standard textbooks. Just as children need the opportunity to learn from mistakes, so students need an environment for learning mathematics that provides generous room for trial and error. In the long run, it is not the memorization of mathematical skills that is particularly important--without constant use, skills fade rapidly--but the confidence that one knows how to find and use mathematical tools whenever they become necessary. There is no way to build this confidence except through the process of creating, constructing, and discovering mathematics. (p. 60)

Teachers' roles should include those of consultant, moderator, and interlocutor, not just presenter and authority. Classroom activities must encourage students to express *their* approaches, both orally and in writing. Students must engage mathematics as a human activity; they must learn to work cooperatively in small teams to solve problems as well as to argue convincingly for their approach amid conflicting ideas and strategies. (p. 61)

There is a price to pay for less directive strategies of teaching. In many cases, greater instructional effort may be required. In those parts of the curriculum where mathematics directly serves another discipline (for example, engineering), students may not march through the required curriculum at the expected rate. In the long run, however, less teaching will yield more learning. As students begin to take responsibility for their own work, they will learn *how* to learn as well as *what* to learn. (p. 61)

Common Question/Responses Raised by Interested Faculty:

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Q: I've never done anything like this before. How do I begin?
R: Slowly, and with help. Remember, you do not have to teach writing; you are using writing to encourage learning. Most instructors, even those who express interest are uncomfortable with these new assignments. They need to realize that the process is just as uncomfortable for students whose expectations in technical classes has typically been to remain passive and to rely on the instructor for answers. The instructor's role changes to one of cheer leader, guide, mentor. It is overwhelmingly tempting to answer student's questions, to force them down certain roads, to give them the solution immediately. The best advice: talk to your peers within the department and in the writing department. Be prepared for frustrations, but also for amazingly professional results from your students. Students are capable of incredible quality. This approach offers exciting challenges to teacher and student alike.

Q: Show me some proof that this technique really is better than straight lecturing.
R: We refer to the findings of the final research report of our *Writing and Problem–Solving Across Disciplines* report. While much of the information is anecdotal, the most instructive comments are from the students themselves. We believe that students are very insightful observers of their own understanding.

Q: How do I write a writing assignment?
R: Again, we cannot underestimate the obvious resources your peers in both the writing department and your own discipline offer. Key issues include explaining who the audience is and trying to be as explicit as possible with instructions. Bounce assignments off other people for feedback and improvement. Then try them with students and ask for their help, as well. Both you and your students will get better at this as you learn from each other.

Q: How can I grade writing, I'm not a writing instructor?
R: You need to talk with your colleagues in the writing department. We have learned a number of things here and it would be good for your faculty to discover their own clues. Among others, we emphasize concepts like audience, clear explanations, appropriate use of examples, graphs, charts, and other visuals much more than punctuation and spelling. We expect papers to have the basic readability of a writing paper. We encourage our students to take their work to a writing lab for analysis. By working with our writing colleagues, we hope to make them aware of our expectations so they can help our students with their writing.

Q: How do I get the time to read all that stuff?
R: It is true that reading student writing offers new challenges to instructors used to assessing other types of student work. The use of a grade/comment sheet helps make the task manageable. Group assignments obviously make for fewer papers. Writing questions on exams take time to grade, but students who develop their skills at writing do become much better at expressing themselves and those papers are *easy* to read. Writing assignments can be used in place of, not in addition to traditional plug–and–chug homework assignments.

Q: If they work together, how will I know how to grade the individual student?
R: The requirement that each member of the team understand the content of the group paper is important to reinforce. Students will try harder to please their peers than the instructor. They cannot take the level of knowledge of the reader for granted as they often, unconsciously do when writing only for the instructor. As far as holding students accountable for group work, exam questions always appear on crucial aspects of any group assignment.

Q: If I take the time to assign writing assignments, how will I cover all the material students need for the next class?
R: The jury is still out on this one. By doing less *for* the student in class, you encourage critical thinking and learning on their part. These new assignments, especially in a group activity setting, get students to think longer and deeper about concepts. They have to communicate with each other and focus on what they do and do not understand. The effect is a far more thorough understanding than traditional regurgitation homework assignments offer. Is this a loss?

Sample Assignments and Student Responses

- Class Survey Form (at beginning of any math class)
- Group Exploration: Problem Solving (with suggestions for use)
- Sample Writing Assignment 1 (American Academy of Pediatrics)
- Sample Student Response 1
- Sample Writing Assignment 2 (Venn Diagrams)
- Sample Student Response 2
- Sample Group Quiz
- Sample Writing Homework Assignments
- Calculus Project Overview
- Sample Calculus Project
- Sample of Student Solution (Partial)
- Sample grade/comment sheet

MATH 105
INITIAL COURSE SURVEY

NAME:

MAJOR:

LAST MATH CLASS:
WHEN LAST MATH CLASS WAS TAKEN:

REASON FOR TAKING THIS COURSE:

IN THE SPACE PROVIDED, DEFINE WHAT THE WORD "MATHEMATICS" MEANS TO YOU.

IN THE SPACE PROVIDED, DESCRIBE YOUR CURRENT FEELINGS ABOUT MATHEMATICS

GROUP EXPLORATION
PROBLEM SOLVING

1. How many handshakes would be needed so that each member of your group shakes hands only once with every other member of your group?

2. What if your group consisted of 5 people?

3. Develop a table showing how many handshakes would be necessary so that each member of your group shakes hands only once with every other member of your group if your group consisted of

   a. 6 people.

   b. 7 people.

   c. 10 people.

4. Develop a pattern to determine how many handshakes would be necessary so that each member of your group shakes hands only once with every other member of your group if your group consisted of 100 people.

5. Be ready to explain your strategy and conclusions to the rest of the class.

GROUP EXPLORATION
PROBLEM SOLVING

SUGGESTIONS FOR USE

We usually use this group activity on the very first day of class, before students have read Section 1.1 or formed any notions of what the course is about. We ask students to take a few moments to introduce themselves to those sitting around them. Since one of the themes of the course is to encourage students to work together and to share ideas, this is a perfect time to get them used to the idea that the other people in class are their allies.

After taking about five minutes for the introductions, we then pose the question, "Since you didn't all get a chance to shake hands and introduce yourselves to everyone in the room, just how many handshakes would that take?" Discuss the problem, define it, encourage students to call out their comments. Some students may have an idea of how to proceed, but almost no one will try to analyze a simpler problem, make a table, look for patterns, speculate on the final answer, etc. in any systematic way. After listing some of their responses and trying to get them to explain the reasons for their answers, we usually propose an experiment. We start with just two students and ask, "How many handshakes are needed?" We act it out with two, then three students.

At this point, we break into groups of three or four. Students will often need encouragement to move their chairs and form groups. We sometimes have to literally drag the chairs of reluctant students into position so the members of the group can look one another in the eye, introduce themselves again, and begin to fumble with the problem–solving process. It is worth the effort and it becomes less and less of an issue as the term goes on.

They will look to you for the right answer, but it is our intent to give them confidence to ask questions, to speculate, to test their hypotheses, to explain their reasoning to one another, and to look to the instructor more for stimulus to think than as the holder of *the* answer. After fifteen or twenty minutes, we call on each group to offer a solution and to explain their reasoning. Rarely will a group have developed an algebraic solution, but we are amazed every time we teach the class at the different approaches students develop. We insist on clear explanations, giving the group time to articulate their thoughts.

This first attempt to introduce new expectations into a mathematics course can be awkward; uncomfortable; and, depending on the class, frustrating. Don't give up. As students become more and more involved and come to expect such group explorations, they learn to enjoy the encounters as a welcome contrast to straight lecture presentations. By consistently and matter–of–factly expecting different behaviors, students will adapt to the expectations, though not necessarily easily.

It has been our experience that even timid students often have something to offer when involved in a small group of peers rather than being forced to speak in front of the whole class or perform on structured and time–limited exams. Sometimes the most surprising problem–solving approaches come from the students who would do the worst in a traditional classroom setting.

The general solution, if the group consists of (n+1) people is

$$1 + 2 + 3 + \ldots + n = \frac{n\,(n+1)}{2} \text{ handshakes}$$

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Sample Writing Assignment 1

Consider the following editorial that appeared in a recent newspaper:

> *The (American Academy of Pediatrics) announced this week it will lobby for a ban on both handguns and assault weapons, pointing out that more than 4,000 youngsters a year die because of them. . . .*
> *What prompted the 42,000–member academy to take a stand is what's happened in recent years. Not only did more than 4,000 youngsters ages 1 to 19 die in 1988 because of handguns, that figure is a full one–third larger than it was three years earlier. If the trend continued, you might expect that 12,000 youngsters died because of handguns just last year (1991).*

Examine the mathematics used by the writer to reach his/her conclusions. If the mathematics used in the article is correct, explain how the conclusions reached in the editorial follow from the mathematics. If the mathematics used in the editorial is somehow faulty, explain wh·· correct the mathematics, and draw an appropriate conclusion from your work. In either case, explain what the long term implications, say 30 years from now, would be if the trend discussed in the editorial continues?

Sample Student Response 1

Writing assignment:

Not only are the numbers in the editorial frightening as presented, but so is the mathamatical reasoning of the editoralist who wrote the article.

The American Association of Pediatrics states that 4,000 youngsters die because of handgun and assult weapons. They also state that this figure is 1/3 larger than the same statistic was just three years eariler. That means that in three years the increase was 1,000 deaths. (3,000 + 1/3 of 3,000 = 3,000 + 1,000 or 4,000).

However, the editor extrapolated the 4,000 of 1988 into three times that or 12,000 in 1991. If indeed there is an increase of 1/3 in three years, the figure would not be 12,000 but 5,333 in 1991. (4,000 + 1/3 of 4,000 = 4,000 + 1,333 or 5,333).

If it continues to increase at 1/3 per every 3 years, in 30 years (the year 2021) the figure would be: 94,705

Year	Increase of 1/3	Tripple every 3 Years
1991	5,333	12,000
1994	7,111	36,000
1997	9,481	108,000
2000	12,642	324,000
2003	16,856	972,000
2006	22,474	2,916,000
2009	29,965	8,748,000
2012	39,954	26,244,000
2015	53,272	78,732,000
2018	71,029	236,196,000
2021	94,705	708,588,000
2024	126,273	

These figures are frightening enough! But the editor would have had them trippling every three years, making them 708,588,000 in the year 2021!

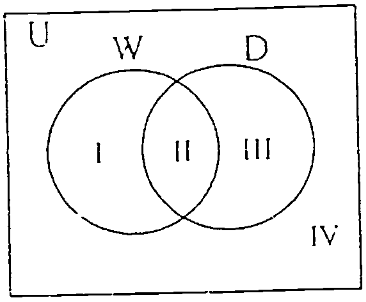
Sample Writing Assignment 2

A telephone poll conducted over the weekend sought to establish the preferences of a sample of 500 people on a recent action by the President. Each of the 500 respondents was asked two questions:

- **Answer yes or no:** **Are you a woman?**
- **Answer yes or no:** **Do you favor the President's decision to lift the ban on the dissemination of information on abortion at government facilities?**

1. Construct a Venn diagram that will allow the answers to be sorted into appropriate sets. Clearly label the sets that you use.
2. Explain why you chose the sets that you did. Explain, in detail, why you do not need more sets to develop a model of this problem.
3. Label each distinct region of your Venn diagram. Provide a verbal description of which people occupy each region in your diagram.
4. Describe each distinct region of your Venn diagram using the set notation of union and intersection.
5. Make a copy of your Venn diagram. Shade the region(s) of your diagram that corresponds to all of the respondents who are *not* women *and* who do not support the President's decision. Explain why you shaded the region(s).
6. Make a copy of your Venn diagram. Shade the region(s) of your diagram that corresponds to all of the respondents who are women *or* who do support the President's decision. Explain why you shaded the region(s).

Sample Student Response 2



U = respondents to telephone poll
W = respondents who were women
D = respondents who agreed with President's decision to lift the ban on dissemination of information on abortion at government facilities

I chose W to represent women polled since the first question asks if the respondent is a woman. Men (non women) can be represented by W' which is everything outside of W. Therefore, both sexes are covered by one set W.

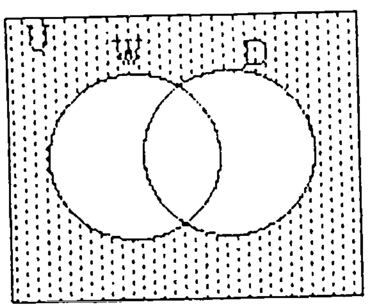
I chose D to represent respondents in favor of the decision because to me favoring the decision shows a person is (aligned) within D. Those not in favor are found in all areas outside D and are represented by D'. D (and its complement), therefore, covers all opinions–in favor or not.

Region I contains women respondents who were not in favor of the decision (in W but not in D) — $W \cap D'$

Region II contains women respondents who were in favor of the decision (in W and in D) — $W \cap D$

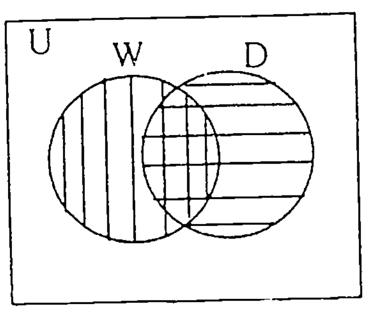
Region III contains men (non women) who were in favor of the decision (not in W, in D) — $W \cap D$

Region IV contains men who were not in favor of the decision (not in W, not in D) — $W \cap D'$



The shaded area represents respondents who are *not* women and do *not* support the President's decision. If they are *not* women (they are men), they are *not* within W. In addition, they do *not* support the President's decision, so they are *not* within D

In set notation: $W' \cap D'$



The shaded areas represent respondents who are women *or* who do support the President's decision. *All* of the women are in the area shaded with vertical lines (W). *All* of those who supported the President's decision are in the area shaded with horizontal lines (D). The area which is shaded twice represents respondents who fit into both categories ($W \cap D$).

In set notation: $W \cup D$

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Sample Group Quiz

1. EXPLAIN WHAT IS MEANT BY A *GAUSS PROBLEM*.

2. GIVE AN EXAMPLE (NOT DISCUSSED IN CLASS) OF A SUM OF NUMBERS THAT CONSTITUTES A *GAUSS PROBLEM*.

3. GIVE AN EXAMPLE (NOT DISCUSSED IN CLASS) OF A SUM OF NUMBERS THAT *DOES NOT* CONSTITUTE A *GAUSS PROBLEM*. EXPLAIN WHY IT IS NOT A GAUSS PROBLEM.

Sample Writing Homework Assignments

1. A fascinating and controversial article titled, *Misconceptions about the Golden Ratio*, by George Markowsky appeared in Volume 23, No.1, January 1992, of ***The College Mathematics Journal***. Write a summary of the author's claims concerning the misinformation about the Golden Ratio.

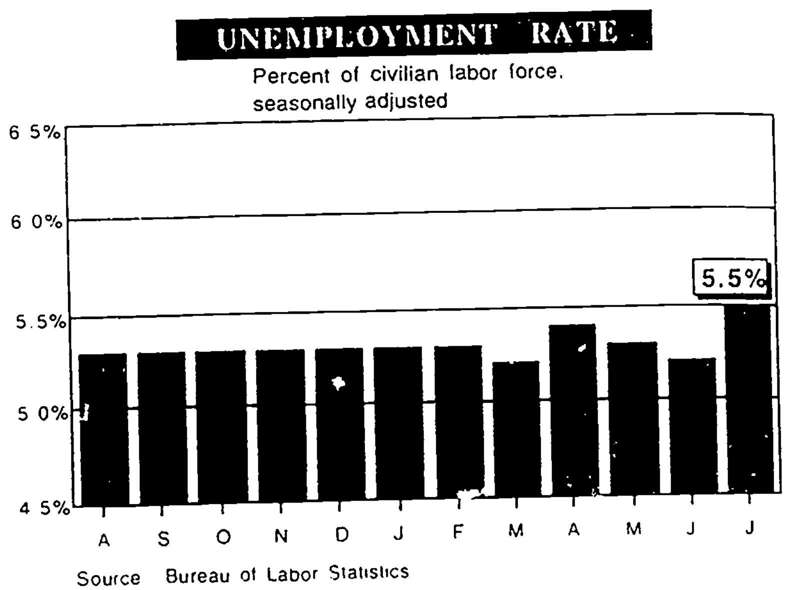
2. An old mathematics problem recently caused a great deal of controversy in the popular press. It's hard to believe that there *could* be controversy over a math problem. After all, math problems are always cut and dried. Or are they?

   Here's the problem, as it was first stated in the column, *Ask Marilyn*, in the magazine section, *Parade*, of the local newspaper:

   Suppose you're on a game show, and you're given the choice of three doors: Behind one door is a car; behind the others, goats. You pick a door, say No. 1, and the host, who knows what's behind the doors, opens another door, say No. 3, which has a goat. He then says to you, "Do you want to pick door No. 2?" Is it to your advantage to switch your choice? Explain your reasoning.

3. You've just been hired to write a description of *Pascal's Triangle* in ***The Compleat Problem Solver's Guide to Mathematical Terminology***. Write a concise but complete description for the text. Provide at least one example (not given in the book) to illsutrate how Pascal's triangle can be used to solve a problem of the type discussed in this section.

4. The following graphic purports to show a comparison of the unemployment rates for August - July.



   a. Judging from the heights of the rectangles, the unemployment rate for July appears to be about 1.5 times that for June. Is this analysis reflected in the actual percentages that are listed? Why?
   b. What is causing this visual distortion?
   c. Construct a bar graph that gives an accurate portrayal of the monthly comparisons.
   d. Suppose you've just been hired by the current administration to redraw the graph - using the correct numbers, of course - in a way that shows a minimal change in the rate for the year. Draw this graph and explain how you achieved the visual imagery that they wanted.

5. Your mathematics study group has asked you to provide an explanation of both *Pie Charts* and *Pictographs* . Explain to the members of the study group how each of these displays is constructed and provide at least one example (not found in this text) to illustrate your descriptions.

6. Congratulations, you've just been hired by the proprietor of a toxic waste dump in New Jersey to redraw the bar graph shown in figure ** (data shown in figure ***) to show the comparison between New Jersey, California, and Michigan. Your task is to somehow redraw the graph using the correct figures, of course, but to show a minimal difference in the number of sites between these three states. Complete your task and provide a detailed explanation of how you accomplished this feat.

7. Condolences, you've just been fired from the job given to you in exercise 6. But not to worry, a toxic waste disposal firm in Indiana has just seen a sample of your work and has decided to hire you to provide a comparison between Indiana, Minnesota, and Michigan. Your task is essentially the same as before: redraw the graph using the correct figures, but to show an exaggerated difference between the number of sites in Indiana and the number of sites in the other two states. Complete your task and provide a detailed explanation of how you accomplished this feat.

8. Look in your local newspaper, a national publication, or other source and find three examples of the use of graphics to display information. Discuss the good and bad points of your examples in light of the discussion in this section.

9. Data compiled within a human services agency indicates that 6% of the children living in a large metropolitan area can be classified as "abused." Two separate studies by the agency, one year apart, suggests that 40% of the children cited in the first study as "abused" can be cited as "abused" in the second study as well, while 94% of the children cited in the first study as "not abused" can still be cited as "not abused" in the second study. Assuming this trend continues, what are the long term implications suggested by the transition matrix?

10. As public funds supporting education have inevitably diminished, most colleges look for donations from private citizens to help meet their rising costs. A common recipient of these funds are college foundations.

    When the director of the foundation at a small community college reviewed the data from the last two fundraising efforts she noticed the following trends:

    > Of the several hundred individuals and businesses who are on the mailing list, 4% are donating at least $1000 to the college on an annual basis, 34% are donating an amount less than $1000, and 62% of those contacted by the foundation are making no contributions to the college.

    When she compared the contributions from last years campaign with this years campaign she found this:

    > Of those who donated at least $1000 last year, 97% made the same donation this year, but 2% donated less than $1000 this year.
    >
    > Of those who donated less than $1000 last year, 8% are giving at least $1000 this year and 85% kept their donations at less than $1000.
    >
    > Of those who did not donate last year, 93% still did not donate this year, but 6.5% are now making donations of less than $1000.

    a. Assuming the campaign stays pretty much as is, what can she expect to happen in each of the next two campaigns?
    b. What are the long term implications?

MATH 251
Projects: An Overview

Group projects and formal writing of mathematics are new to most of you. I **do not expect** that you will automatically know how to complete these assignments. I **do** expect you will need help. Understanding all the details and implications of the projects will take a significant effort. "Spinning your wheels", taking "wrong turns", struggling and becoming frustrated are a normal part of the learning process. However, as you gain familiarity with a problem, your struggling will diminish. Similarly, over the course of the term your proficiency with these projects will increase. In general, you will learn the most through constructive feedback from your peers. Thus, you are encouraged to collaborate with anyone and everyone. Feel free to contact me with questions, both during class and outside class. As your instructor, it is important to me that you understand fully what the purpose and procedures are. This handout attempts to explain the expectations for projects.

Purpose of Projects

- Improve your problem-solving skills by working on open-ended problems.
- Learn methods of *Mathematical Modeling*.
- Give you a new perspective on the course material.
- Give you experience working as a team.
- Encourage your creativity.
- Give you experience communicating mathematical concepts through technical writing.

Evaluation

- Each project is worth 100 points.
- Evaluation is divided into three equally weighted categories:
  - 1/3 for clarity, neatness and overall appearance of report.
  - 1/3 for mathematical rigor.
  - 1/3 for creativity and approach to the problem.
- Generally, each person on the team will get the same grade. However, exceptions may occur if the effort is not reasonably distributed.
- With each project report a journal/diary detailing your efforts should be included. The Journal should include a chronological narrative of your team's meetings and activities: who did what, bcth positive **and** negative results. Journals may be ***neat*** handwritten notes.
- Each member of the team will submit an assessment of each group member's contribution.
- Each student should expect exam questions related to the projects.
- There will be a substantial penalty for lateness at the discretion of your instructor.

Teams

- In general, teams will consist of 3 members.
- I reserve the right to change a team at any time; those not on a team I will arbitrarily assign to a team.
- I strongly suggest that you include someone familiar with a word processor on your team.
- I strongly suggest that you include someone familiar with programming the TI-85 calculator.
- It is essential that each team member understand the details of their final report.

Final Report Guidelines

Title Page--include title of project, project participants, course, term, date, etc.
Table of Contents--include Headings, Figures, Charts, etc.
The Problem Abstract
State *"The problem" as concisely as possible*. Consider the following example:

Using Logarithms to Explore Power and Exponential Functions

Power functions and exponential functions often describe the relationship between variables in physical phenomena. Power functions are equations of the form $y = kx^n$, where k is a nonzero real number and n is a nonzero real number not equal to 1. Exponential functions are equations of the form $y = k\,b^x$, where k is a nonzero real number and b is a positive real number. When physical phenomena appear to describe exponential and power functions, logarithms can be used to locate approximate functions that represent the phenomena. This paper will explore some activities that have helped our students make visual generalizations about power functions and exponential functions. In addition, we will examine some methods that have helped our students determine an approximate function represented by data.

The Mathematical Model

Define the variables, parameters, data. List restrictions to which you must adhere (e.g. "The result holds only for positive real numbers."). List any assumptions you are making. There are *usually* assumptions which you may have taken for granted (e.g. Is 'g' really constant?). Think about your assumptions carefully. Are they realistic? What do they imply?

Formulate your model mathematically. Restate the problem in terms of its variables. Include carefully labeled graphs and tables.

The Results

Generate a solution. Give details of the major solution steps in your solution. Does the solution make sense? How well does it fit the physical problem? Be sure to include an error analysis and the effects of restrictions and any simplifying assumptions. Test your results. Give the results of your tests.

Conclusions

What can you infer from your solution? What are its limitations? Were the assumptions too restrictive? What conclusions can you draw about your problem, about your model, about your solution procedure? What further questions for investigation could you suggest?

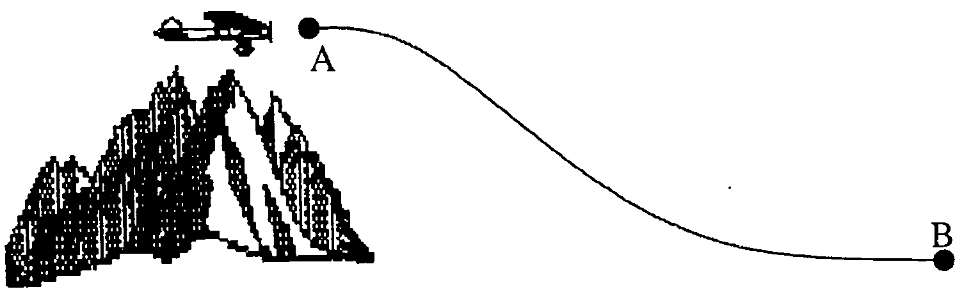
Report Formatting Guidelines

There are some formats that are easier to read and follow than others. This, of course, affects your grade. Many of you will be expected to conduct similar projects and write reports in your careers. I have summarized those features which I feel should be included in your reports.
For best results:

- Keep your audience in mind.
- Use Headings; for example:
- Headings in CAPITALS, **BOLD** , <u>underlined</u>, or otherwise highlighted.
- Place figures, charts and tables where convenient for the reader.
- Include an explanation for the figures, charts and tables on the *same* page if possible. Large amounts of data, charts or figures should be in an appendix.
- Number, figures, charts and tables for reference. Equations and calculations should be numbered (they may be grouped). See any textbook for examples.
- Use bullets (•) or enumerate to highlight major points or to make lists more readable.
- Run spell checker when using a word processor.
- One of you should write your rough draft (or have each person do a section)
- **Each** team member should then proofread and edit it to get a final draft.
- Ask someone not associated with your team to proofread it for clarity.

Sample Calculus Project

M251
Group Project



Background
To increase tourism the town of Dilly-Dally Valley wants to build an airport at the base of the Pickle Mountains. You have been hired to do a feasibility study of finding a flight path for an airplane coming over the Pickle Mountains and landing at the new Dilly-Dally Valley airport.

Task
Planes will come over the mountains at a relatively high altitude (point A) and must get to the relatively low altitude at the head of the runway (point B). Points A and B are given. However, due to the variable nature of flight restrictions, you should allow for the possibility of changing points A and/or B. For example, the Chamber of Commerce would like to move the airport closer to the mountains and the pilots would like to come over the mountains at a higher elevation in bad weather.

We wish to apply the concepts of functions, continuity, position, velocity and acceleration to air traffic control. Assume you have some initial position and you wish to attain a second position. Some restrictions apply to your path connecting these points. Can we set up a scheme which will give us this path and obey all these restrictions? This is your task. Working in groups of 3 you will develop a **scheme** by which you can generate a sequence of paths $p_1, p_2, p_3 \ldots$ which obey a set of fixed restrictions.

Restrictions
- Due to the small runway, the *horizontal velocity* at B must be no greater than 120 mph.
- To keep the plane from stalling, the *horizontal velocity* between A and B must be no less than 120 mph.
- At point A the airplane has a *horizontal velocity* of at least 400 mph.
- The plane should *decelerate horizontally* at no more than 4 ft/sec^2.
- The plane should *accelerate downward* vertically at no more than 8 ft/sec^2.
- The *horizontal distance* from A to B is 12 miles.
- The *vertical distance* from A to B is 6,000 ft.
- The flight path should be "reasonably smooth".
- You may include additional restrictions if you like.

Apply your scheme to at least one **example** of your choosing. Write a report which details your scheme and a sample flight path. This report should assume a formal tone towards an uninformed reader. Be aware that this procedure will pertain to creating any object/shape (flight path, automobile, airfoil, hiway interchange, font, etc.) which you wish to have obey certain characteristics.

In addition to the report, you **must** include a group journal or individual journals outlining your time/steps/progress. Also, you **must each** include an evaluation of the contribution of each group member towards the total project.

Sample Student Solution (Part)

HISTORY AND BACKGROUND

The town of Little Funk Valley is building an airport at the base of the Big Calk Mountains. Our job is to find a workable flight path for planes coming over the mountains with an altitude of 6000 feet (point A on Fig 1) to land safely 12 miles away horizontally from point A with an altitude of zero feet (point B on Fig 1)

WHAT DO WE KNOW ???

- Due to the small runway , the horizontal velocity at B must be no more 120 mph (176 ft/s)
- The horizontal velocity between A and B must be no less than 120 mph (176 ft/s)
- At point A the airplane has a horizontal velocity of at least 400 mph (586.6 ft/s)
- The plane should accelerate horizontally at no more than -4 ft/s^2
- The plane should accelerate vertically at no more than -8 ft/s^2
- The horizontal distance from A and B is 12 miles (63,360 ft)

We're assuming the plane is flying level at point A and B, so the vertical velocities at point A and B are 0 ft/s. Also, in order to simplify the problem, we're assuming the acceleration in the (X) direction (horizontal) to be constant. Below is a list of variables representing the parameters of the problem:

$X(t)$ = horizontal position of the airplane as a function of time.
$Y(t)$ = vertical position of the airplane as a function of time.

$[X(t), Y(t)]$ = position of airplane at any given time (t).

0 = time initial　　　　t = any time between 0 and time final
T = time final

$X(0)$ = initial horizontal position relative to the origin = 0
$X(T)$ = final horizonal position relative to the origin = 63,360 ft
$Y(0)$ = initial vertical position relative to ground = 6,000 ft
$Y(T)$ = final vertical position relative to ground = 0 ft
V_{iy} = the initial vertical velocity at 0 = 0 ft/s
V_{fy} = the final vertical velocity at T = 0 ft/s
V_{ix}= the initial horizontal velocity at 0 = 586.6 ft/s
V_{fx} = the final horizontal velocity at T = 176 ft/s

Sample Grade/Comment Sheet

PROJECT 1

EVALUATION FORM

	Excellent	Good	Needs Revision
ABSTRACT Statement of Problem			
MATHEMATICAL MODEL Clear Definition of Variables			
Restrictions			
Assumptions			
Figures/Graphs			
Grammar/Spelling			
Overall Layout			
Readability			
THE RESULTS Level of detail shown			
Accuracy/Validity			
Effect of Restrictions			
Programs Used (listings)			
CONCLUSIONS Discussion of limitations			
Other conclusions			
Further questions			

Presentation: Bruce Emerson
Physics Department
Central Oregon Community College

Writing in Physics: A Vehicle for Evaluating Process.

Motivation:

Physics is, by its nature, a problem solving class
- needed by students who go on to classes where instructors have clear expectations about what they learned in physics
- can lead to students learning how to manipulate the numbers without understanding
- sometimes emphasizes the specific types of problems and misses the general picture.

Conceptual and Process understanding is desired!
- can the students apply what they are learning to real, which is to say poorly defined, problems?
- do they understand what they are learning well enough to articulate it clearly to someone else?
- do they, in fact, understand the material?

I have made writing a part of my physics classes in an attempt to deal with this dichotomy and address student understanding of the concepts and processes in physics.

How?

For me the natural place to include writing has been in the lab portion of the course.
Each lab serves two purposes:
- to apply recent material from the classroom to moderately real situations
- to experience some facet of 'real' scientific investigation

The students give me back a written lab report through which they demonstrate their learning in these two focus areas.
I grade the labs for both physics content and effective communication of the underlying processes and concepts.

Implementation Barriers:

Factors which make implementation difficult in physical science fall into two classes - physical resources and work environment

Physical resources
- major investment in specific lab equipment for particular experiments (is all this equipment now wasted?)
- limited budgets for new materials to support new style
- existing lab manuals are easily available and coordinated with standard course curricula

Work environment
- short term investment of time to redesign the labs (5 yrs)
- long term increase in evaluation time and effort
- institutional support for changing work load
- uncertain risk/benefit picture
- support of colleagues

Lab Guidelines:

As a result of WAD discussions the guidelines were created to try and connect with the writing classes
Not all students have had writing 121 at this point and we have not made it a prerequisite.
Intended to clarify terms and expectations
Supplemented with pre-lab discussions and feedback

Sample Assignments and Student Responses

- Evaluation process
- Lab 3 assignment (intro section and uncertainty analysis)
  - good response (very successful student)
  - poor response (student w/ writing skills but in wrong class)
- Sample grade sheet

LAB REPORT GUIDELINES FOR PHYSICS
INSTRUCTOR: DR. BRUCE EMERSON

Basics:

There are three purposes we are trying to accomplish in physics labs. The first is to gain some insight into a variety of physical principles. The second is to learn something about the process of scientific investigation and verification. Finally we need to learn how to communicate what we know or have seen. Your lab report is the vehicle by which I can find out how well these purposes are being accomplished.

Because the lab report is intended to convey what you have discovered it needs to be written and organized like any other writing assignment. Your name, lab section, lab title, and date should appear prominently at the beginning of your report. Throughout your report it is important to label your data tables, plots, and figures so that all of us who might read it can identify the information. It is often helpful to label sections of your report to correspond to the tasks I have asked you to complete. This will help you avoid overlooking some particular task.

When you write your lab report imagine that the reader is a fellow student not currently enrolled in physics. By the end the reader should have a clear idea of what you did as well as the implications of the experiment. If I were to hand the necessary equipment to your reader they should be able to set up the experiment based on your report. Simple drawings can be of great help! Data that you take needs to be organized and presented clearly. This is important because it helps me identify difficulties your may have had with the lab and also avoids confusion on your part. When writing up conclusions try to construct a logical argument based on your data. I am more concerned with the self-consistency of your argument than with its absolute correctness. Avoid terms like 'obviously', 'clearly', 'of course', and 'it is well known'. Such terms denigrate the reader and tend to raise suspicions about your knowledge.

I will accept handwritten lab reports during fall quarter but as of winter quarter all reports must be typed. You all have access to computers here on campus and most of you have some experience with a word processor. In this day and age it is important that you become as comfortable with the basic features of computers as you are with your pencil. This does NOT mean that I expect you to know how to make tables, graphs, and do formulae on the computer. Those of you who enjoy such things may do so but for the rest, just leave some space in your document and draw the data tables, draw the graphs, and write in the formulae. Come talk to me if you have concerns about this issue.

Grading:

The lab reports will be worth 20 pts each. If you do just what I ask for and no more you will receive a maximums of 14 pts (like a C). The extra 6 pts are for those who go beyond the minimum requirements in thought, creativity or effort. Fear not, I am not nearly as draconian as I sound. The basic items that I will be looking for are as follows:

i) Did you do everything I asked you to?

ii) Did you answer all the questions fully and completely? This is one place where thinking more deeply and writing about it will get you additional points.

iii) Can I figure out what you did? This seems straightforward but I often get reports where I can barely tell what is going on. In some cases I would swear the student was in the wrong class!

iv) Did you reach beyond the scope of the lab to relate the material to other experiences you have had or material in class? Did the lab provoke you to ask some thoughtful questions?

Terminology:

A common difficulty that students have is understanding what I expect when I use certain terms. These are the same terms that you have seen (or will see) in WR121. I will give you my working definitions of these terms to see if we can get off to a good start. Terms which are not in general use in writing classes will also appear on this list.

describe: Tell me about the noticeable features of whatever it is. Does it go up or down? Is it big or small? Small relative to what? Is there anything unexpected about it?

compare: Tell me about the similarities between the items I asked you to compare. Tell me about the differences. Do the similarities or the differences dominate? Does this seem reasonable to you? If you are comparing your experiment to the classroom discussion tell me if the they agree. If they agree, how well do they agree. If there is some inconsistency search for possible explanations.

discuss: I want you to explain to me in some detail what you are observing and why this does or doesn't make sense. It should be easy for me to understand the logical progression of your thoughts.

estimate: By this I mean find a reasonable value for the quantity desired using the numbers at your disposal. When you tell me its about 0.5 miles to your house, that's an estimate. You know that you could be off by hundreds of feet but you have communicated to me a good sense of how far I have to go to get there. The meaning of a reasonable estimate is a subjective judgment on my part.

uncertainty: The uncertainty in a measurement is magnitude of the possible error in you measurements. In your labs you will often be asked to estimate the uncertainty in some measurement. To do this you need to have a sense of the possible errors in the various parts of your measurement. Suppose you estimate the hallway to be 100 ft long by counting body lengths, and I then want to estimate my uncertainty. I'm sure its not 150 ft long (1/2 a football field) or less than 60 ft so at worst I'd estimate my uncertainty at 40 ft but I'll bet I'm within 20 ft (three body lengths). Suppose I made the same estimate by counting the tiles on the floor. Now I would expect my estimate to be off by less than 2 ft since I probably didn't miscount by more than three 8" tiles.

resolution: The resolution reflects the ability of your measurement tool to indicate the value of your measurement A ruler which has divisions every 1.0 mm has a resolution of 0.5 mm. Those of you who think you can do better have been indulging in too many recreational substances! If you are counting your marbles the resolution of the measurement is 1 marble - either you have one or you don't. Your uncertainty might be 3 marbles because you get a different number each time you count.

Time Management:

Many students find that they spend a great deal of time on their lab reports. It is not unusual for students to spend 6 hrs on a report. This is not my expectation. It is important for you to learn how to budget a reasonable amount of time for completing the lab and then turn it in. I expect 2-3 hrs is appropriate if you expect to get between 14 and 16 pts on the lab. To do this you will need to think clearly and write efficiently. The pay back is that most students find that the process of writing the lab helps crystallize their understanding of the physics being studied. The labs are due on Friday so that you will have the weekend available for homework. Most students find it more difficult to write up labs on Thursday night than to do them Tuesday or Wednesday so help yourself and get with it.

Lab #3: PH 211

Purpose: The overt purpose of this lab is to explore practical uses of 1-dimensional kinematics. Perhaps more importantly this lab is an opportunity for the student to experience the process of defining and executing an experiment to measure a particular quantity. This lab will be graded on your ability to figure out a plausible means of completing the assigned task, making the measurements in a way which minimizes any inherent uncertainties, and presenting the results in a coherent and comprehensive manner.

Discussion: Everybody has been on top of a tall object at some point and wondered how high up they were. (bridges, mountains, cliffs, buildings, etc.). There are several ways to accomplish this. What is most important in this lab is the process of deciding what to do, thinking out the physics and math involved, and executing the experiment with an awareness of the various sources of uncertainty in the process. The tools at your disposal to make this measurement are going to be limited so that you will do some physics at the same time. So how do we design and execute an experiment or measurement. First you have to decide what tools are at your disposal. Is it possible, with these tools, to make the desired measurement? If it seems like it is then a trial calculation is in order. Make up some data like that you plan to collect and see if you can complete all the calculations. Often times you discover during a trial calculation that you need more information. After checking to be sure you can generate the additional information you need you can proceed to do the actual experiment. During the execution of the experiment you need to be aware of all the factors which might cause your data to vary. These will later be used to support your analysis of the uncertainties in your data. It is often helpful to perform little tests to determine the effect of small changes in your data.

Procedure: Your task is to find two ways to measure the height (from the ground) of the railing of a landing behind the library. One of your methods must utilize trigonometry and the other must utilize 1 dimensional kinematics and the modified pingpong ball(hint: try dropping something). Your may use other methods as a cross-check if you wish.

1) Decide what equipment you will need to perform your experiment and come talk to me abou. your plans. If your plan seems reasonable I will provide you with the equipment. Be advised that the cables on the photo gates are not long enough to be useful. I reserve the right to change the rules if I think you're avoiding the whole problem. Trading lab supplies to the building superintendent for a look at the blueprints will not be an approved plan! Remember, in keeping with the spirit of the problem, that you should be able to use your techniques to measure the height of a object which is difficult to run up and down.

2) Get out there and make those measurements. Please be careful not to damage your fellow students-- you may need their help some day! As you do your experiment consider the uncertainties in the measurements you are proposing to make. Have you considered things like reaction times, angular uncertainties, and individual variation? How will you minimize these effects?

LAB REPORT:

I) Describe the task that you were posed and the two approaches your group took to solve the problem. Be detailed enough so another student could understand the problem and **reproduce** your method but don't get carried away. (more than two pages is getting really carried away!) If it helps, consider what it was you wish I had told you about how to do the lab. How many times should you repeat ? What specific steps did you take to reduce the uncertainty in your data?

II) Present the data that you collected in order to correct for the effect of air resistance. Describe why you took this data and how you intend to use it.

III) Present the data that you collected in a clear and organized way with appropriate labels. Be sure to note any extra data you took to help answer part IV.

IV) Show precisely how you calculated the height of the railing by each of your methods. Calculate the percentage difference between the results of your two calculations. Since you (presumably) don't know the actual height of the railing you can only compare the two values you have calculated.

V) Discuss which of the methods you think is more reliable and why. Estimate the uncertainty in result you think is most reliable. (remember our discussion during the first lab) I expect you to use numbers in this estimate and to justify those numbers that you use.

VI) Tell me what you found most intriguing about the lab.

Student L

The Problem

The task presented to us in this lab involves measuring an unknown height and using three different methods to calculate the height in question.

The first method that we were to use involved the use of a pingpong ball that had a streamer attached to it so that the effect of air resistance would be a major contributing factor in the data collection. The streamer itself causes us to ignore the usual convention of acceleration (9.81 m/s^2). Instead we have to calculate the acceleration of the obscured pingpong ball from a number of known distances to find the acceleration to use for calculating the unknown height.

With the streamer we encountered some unusual problems that greatly affected our calculations. The one problem of greatest concern is that the streamer causes the pingpong ball to "flutter" on its way down. By flutter I mean the ball goes through a sort of cycle as it progresses downward. Over different intervals, the ball experiences increased and decreased accelerations. ....

Student M

Introduction:

The purpose of this experiment is to find two ways to measure the height of the railing behind the COCC Library. This task will be accomplished using equations for one-dimensional kinematics, a pingpong ball, with streamer attached, and trigonometry. The results of both methods will be compared to see which method will give a more accurate answer.

Procedure:

To begin the pre-experimental processm, our team used a stop watch a two meter stick,l and a pingpong ball, with streamer attached. We dropped the ping pong ball at a measurement of .5 meters. We used the stop watch to find the time it took for the ball to reach the floor. The steps our team took to reduce the uncertainties of the data was to take more than one time test for each measurement.

Student L
(Uncertainty)

All three methods give results that are pretty close to each other. In fact, taking the lowest height and the highest height I found them to be within 7% of each other and the third heigth is between those two so all of them are very close. The actual height, I think, is around 7m, if we take that 7m and expend it to the minimum and maximum by 7% the range we have is roughly 6.5m - 7.5m. That gives us a whole meter to say that our answer is the correct one. If our data is not flawed by much I would certainly feel confident with the range of error that we have, being off by half a meter or so is not bad considering the restrictions we had to work with.

Student M
(Uncertainty)

Comparing the two methods, we see that there is a difference of 7.2m - 4.9m = 2.3m. As stated before (ref pg. 3), we contribute the difference in human error. The one-dimensional kinematics appears to be the more accurate of the two methods.

Lab #3 Rock Drop
PH 211

	needs work	ok	great
Overall Clarity	needs work	ok	great
Task Description	needs work	ok	great
- trig method	needs work	ok	great
- kinematics	needs work	ok	great
- reproducibility	needs work	ok	great
Drag Correction - data	needs work	ok	great
- analysis	needs work	ok	great
Data Presentation	needs work	ok	great
Calculations	needs work	ok	great
Uncertainty analysis	needs work	ok	great

<u>EXTRAS</u>

	needs work	ok	great
	needs work	ok	great
	needs work	ok	great

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Course Descriptions
Central Oregon Community College

WS 101
Introduction to Women's Studies
Explores the impact of women's and gender studies in many academic fields. Examines women's status and achievements, and the issues raised for men and women by feminism and the women's movement.
Lecture: 3. Lab: 0.Credits: 3.

Mth 105
Introduction to Contemporary Mathematics
Introduces basic concepts of contemporary mathematics to students who are not planning further study of mathematics. Topics to be selected from: finite mathematics, probability, descriptive statistics and mathematical problem-solving, examples of major mathematical ideas and applications. Topic presentation includes group discovery activities and writing assignments. A major goal of the course is to capture the interest of the liberal arts major while stressing the importance of a working knowledge of math in today's society. Prerequisites: MTH 95 (Intermediate algebra) or equivalent.
Lecture: 4. Lab: 0. Credits: 4.

Mth 251
Calculus I
Introduces the concepts of differential calculus for Science, Mathematics and Engineering students. Topics include: limits and continuity; the derivative; rates of change; the derivatives of polynomial, rational and trigonometric functions; applications including maximum-minimum problems; antiderivatives and definite integrals. Topic presentation includes group discovery activities. Real applications, technical writing, group activities and group projects are emphasized. A programmable, graphing calculator is necessary. Prerequisite MTH 112 or equivalent or instructor's permission. MTH 113 highly recommended.
Lecture: 3. Lab: 2. Credits: 4.

PH 201, 202, 203
General Physics I, II, III
This course studies mechanics, sound, heat, light, electricity and magnetism and offers an introduction to modern physics. Co-requisite: MTH 111 for PH 201; MTH 112 for PH 202 and 203.
Lecture: 4. Lab: 3. Credits: 5.

PH 211, 212, 213
General Physics I, II, III
This course provides a study of mechanics, sound, heat, electricity and magnetism. Designed for students majoring in engineering or the physical sciences. Co-requisite: MTH 251 for PH 211; MTH 252 for PH 212; MTH 253 for PH 213.
Lecture: 4. Lab: 3. Credits: 5.

WR 121, 122, 123
English Composition
Presents the fundamentals of college writing. WR 121 offers the principles of organizing and developing short expository essays. WR 122 focuses on critical thinking skills, with practice in informal logic and argumentative writing. WR 123 stresses research writing, with practice in bibliographic techniques and the evaluation of sources. A three term sequence course.
Lecture: 3. Lab: 0. Credits: 3.