An Analysis of Factors Affecting Student Success in MATH 160 Calculus for Physical Scientists I

Submitted by
Kenneth F. Klopfenstein
Associate Professor
Mathematics Department
Colorado State University
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1. **Contact Information**

   Name: Kenneth F. Klopfenstein  
   Phone Number: 491-6573  
   Email Address: kenk@math.colostate.edu  
   Mailing Address: Mathematics Department, 101 Weber, 1874 Campus Delivery  
   Department Chair Name: Simon Tavener  
   Department Chair Email Address: Tavener@math.colostate.edu  
   Dean Name: Rick Miranda  
   Dean Email Address: rick.miranda@colostate.edu

2. **Total Budget Request:** $6,043.10

3. **Course Number and Title:** MATH 160 Calculus for Physical Sciences I

4. **This course is in the AUCC:**

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<th>Yes</th>
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5. **Course Enrollment:**

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<tr>
<th>Year</th>
<th>Fall</th>
<th>Spring</th>
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<tr>
<td>2005 – 2006</td>
<td>330</td>
<td>188</td>
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<td>2006 – 2007</td>
<td>319</td>
<td>186</td>
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<td>2007 - 2008</td>
<td>431</td>
<td>266</td>
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6. **Identify courses for which this course:**

   Is a prerequisite: MATH 161, MATH 229, MATH 301, MATH/BZ 348,  
   CS/MATH 158, CS 160, PH 141, ECE 325, MECH 102, MECH 237,  
   CIVE 202, CIVE 260, BIOM 470, CBE 201, STAT 321, GEOL 454,  

   Is a prerequisite with a grade of C or better: CS 161, CS 200, CS 270  

   Is a prerequisite with a grade of B or better: n/a

   **Note:** Many courses in the sciences and engineering have a prerequisite of two or more semesters of calculus. The list of courses that have MATH 160 as a “second level” prerequisite would be quite long. 

7. **Course Description and the problem(s) that will be addressed in the proposed redesign.**

   From the CSU General Catalog:
   MATH 160 (4 credits) Calculus for Physical Scientists I. Limits, continuity, differentiation, and integration of elementary functions with applications; conic sections.
   MATH 160 is the first course in a three semester sequence (MATH 160, MATH 161, and MATH 261). All mathematical sciences majors, all engineering majors, and several physical sciences majors require all or part of this sequence. Calculus is the gateway to all of these majors and MATH 160 is the gateway to calculus.
   During the past five semesters (F05, Sp06, F06, Sp 07, F07) approximately 1450 students attempted MATH 160 and approximately 900 (62%) successfully completed the course by
earning a grade of A, B, or C. The lowest success rate was 46% Spring Semester, 2007. This relatively low success rate discourages students from choosing or persisting in scientific and technical majors and is expensive for both students and the university.

The proposed redesign will address the problem of the low success rate in MATH 160.

8. **Redesign Rationale.** Indicate why you are proposing a redesign and how this course might benefit from a redesign, paying particular attention to enhancing student learning and success. Instructors identify many reasons why students do not succeed in MATH 160, but frequently mention that

- students' pre-calculus skills are weak,
- study strategies that students found successful in high school mathematics are not effective for learning university-level calculus; and
- students have unrealistic expectations about the effort required to succeed in a serious university-level mathematics course.

Weak pre-calculus skills and ineffective study strategies are largely independent problems. One student may have weak pre-calculus skills and effective study strategies while another may have strong pre-calculus skills and ineffective study strategies. Different course components are needed to address these two independent problems. We are focusing on one problem at a time. This proposal addresses the first problem: students’ weak pre-calculus skills. A later proposal will focus on students’ unrealistic expectations and ineffective study strategies.

This semester (Spring, 2008) the ALEKS Corporation offered the Mathematics Department free trial use of their web-based, artificially intelligent, pre-calculus instructional software. This semester we introduced a required ALEKS-based pre-calculus proficiency component into MATH 160. We are requesting funds from the Provost’s Course Redesign Competition to

(i) evaluate the effects of the required pre-calculus proficiency component (ALEKS) on students’ success in MATH 160,

(ii) determine whether there is a sub-population of MATH 160 students who benefit most from a pre-calculus proficiency component (and another who gains no benefit);

(iii) investigate students attitude toward the added pre-calculus proficiency component and ALEKS in particular; and

(iv) if a required pre-calculus proficiency component improves student success in MATH 160 as expected, determine whether ALEKS is the most cost-effective way to incorporate this component into MATH 160.

9. **Fit with Department or Program Instructional Goals.** Explain the contributions that might be made to the strategic goals of the department or program by redesigning this course.

A major part of the mission of the Mathematics Department is to provide quality instruction in courses the serve other departments and programs. MATH 160 is one of the most important service courses in the Mathematics Department.

10. **Redesign Process.** Make preliminary suggestions for the solution to the identified problem that would be part of the redesign. Indicate semester(s) in which implementation will begin.

See #8. Implementation began Spring 2008. We are requesting funding from the Provost’s Course Redesign Competition to evaluate the trial implementation of a required pre-calculus proficiency component in MATH 160 and to investigate the most cost-effective way to incorporate a required pre-calculus proficiency component permanently.
11. **Anticipated Outcomes.** Address implementation, potential student learning and success within the course, and contributions made to related courses and/or programs.

See #7, 8 and 10 above.

At this point, just past mid-semester, anecdotal information from instructors indicates that the required ALEKS component has had the desired positive effect. Four of the seven individuals teaching MATH 160 this semester have taught the course previously. These four instructors agree that when we work example problems in class this semester, we get far fewer questions about the details of algebraic manipulations than we have gotten previously.

12. **Assessment Plan.** Briefly explain how the outcomes of the redesign might be assessed.

The project is primarily about assessing the pre-calculus proficiency component incorporated into MATH 160 for the first time Spring Semester, 2008.

We will use attributes of students who took MATH 160 during previous semesters (e.g. ACT/SAT scores, prior calculus experience, major, high school rank in class) to develop a model to predict students’ final grades in MATH 160. We will then use this model to compare students’ predicted final MATH 160 grades with their actual final grades earned Spring 2008. Differences between predicted and actual grades may be attributed to the required pre-calculus proficiency component incorporated into MATH 160 for the first time this spring semester.

We hypothesize that the required pre-calculus proficiency component will result in significantly higher final grades in MATH 160. (The goal is to increase the over-all success rate from about 62% to at least 80%.)

We will also analyze the effect of required pre-calculus proficiency component on different populations of students. If it is found that the pre-calculus proficiency component has a significant positive effect for all MATH 160 students, we will recommend that this component be permanently incorporated into MATH 160. If pre-calculus proficiency component has a significant positive effect for only an identifiable subset of MATH 160 students (e.g. those who did not study calculus in high school), we will recommend an alternate version of MATH 160 that incorporates the required pre-calculus proficiency component for this population.

13. **Dissemination Plan.** Briefly explain how results of the course-redesign project might be disseminated within and across programs of study and, if relevant, to disciplinary communities.

Results will be communicated by personal contacts and written reports to key advisers in all departments and programs that require MATH 160.

Mathematics Department Undergraduate Committee is responsible for monitoring and recommending curriculum changes. This committee will be kept apprised of the progress of the project and their advice sought. Any recommendations for curriculum changes (including significant changes to grading policies or syllabus) resulting from this study will be submitted to the Mathematics Department Undergraduate Committee.

Results of the project will be submitted for presentation at a 2009 spring meeting of the Rocky Mountain Section of the Mathematical Association of America.

14. **Team Members.** Include names, titles and responsibilities.

Ken Klopfenstein, Associate Professor, project coordinator
Daniel Reinholz, Graduate Teaching Assistant, statistical modeling and analysis
Lois Samer, Co-Director of the PACe Program, data retrieval and collection
15. **Departmental Support.** The budget submitted as part of the pre-proposal included summer support for department faculty and staff to coordinate the project and to acquire data from university sources. The Mathematics Department and department faculty will contribute support for these components of the project. Accordingly, requests for summer salaries are deleted from the final budget request.

Mr. Reinholz is currently taking the course EDRM 700 Quantitative Research Methods in Education and therefore believes that consulting services from the Graybill Statistical Laboratory will not be needed. This item is also deleted from the budget in the pre-proposal.

16. **Budget.** Please note that only one course or service release is allowed per project.

**Funded by TILT**

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**16. Signatures.**

Project Leader: _____________________________ Date ______________

Department or Program Head: __________________________ Date ______________

Dean: _____________________________ Date ______________

**17. Current Course Syllabus.** Please attach a syllabus for the course.

**18. Letter of Support.** Please attach a letter of support from the department or program.
“The first requisite for success is to develop the ability to focus and apply your mental and physical energies to the problem at hand - without growing weary. Because such thinking is often difficult, there seems to be no limit to which some people will go to avoid the effort and labor that is associated with it...”

Thomas Alva Edison (1847-1931)

“You don’t have to believe everything you think.”

Anon (seen on a bumper sticker)

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**Instructor:** Mr. Klopfenstein  
**E-mail:** kenk@math.colostate.edu  
**Phone:** 491-6573

**Office:** Weber 121  
**Office Hours:** MTF 1:00 – 2:00 PM and as posted.

**Course Assistants:** Sara Slagle, Steve Ihde

**Prerequisite:** Algebra proficiency

MATH 126. Students who have not completed MATH 126 by 4 PM Friday, 1/25, must drop.

**Corequisite:** MATH 124. MATH 124 is an enforced prerequisite for MATH 161. You must complete MATH 124 to be allowed to take MATH 161

**Registration Deadlines:** Register for lecture and lab in the same time slot.  
Last day to satisfy prerequisites: Friday, January 25  
Last day to add: Monday, January 28  
Last day to “free” drop: Wednesday, February 6  
Last day to W-drop: Monday, March 24


**Calculator:** You will need an advanced scientific/graphics calculator. You will be expected to use your calculator in class and to complete Calculator Labs described below. Some questions on the mid-term and final exams will require a calculator. **Bring your calculator to class every day.**

**Course content:** Limits, continuity, differentiation, and integration of elementary functions with applications. This material is found in Chapters 1 – 6 of the textbook.

**Course goals:** The goals of this course are for you to

* understand the concepts of calculus (explain “why?” and “what’s going on?”);
* become proficient with the techniques, calculations, and procedures characteristic of calculus;
* be able to use techniques from calculus to model “real-world” situations and solve “applied” problems; and
* be able to write complete, well-organized, logically correct solutions to problems and responses to questions.

**Special Needs:** If you have special needs, including accommodation for physical limitations or special accommodations for taking exams, please discuss your situation as soon as practical with your instructor or the Course Coordinator. The Mathematics Department is committed to accommodating disabilities.

**Mid-term exams:** There will be three common mid-term exams given 5:15 – 7:00 PM on Thursday, February 14, Thursday, March 13, and Thursday, April 17. These exams will be in two parts. Part A will emphasize applications and concepts. You will be expected to use your calculator on Part A. Part B will emphasize basic facts and procedures. You will not be allowed to use a calculator on Part B.

Mid-term exams will be scored on the basis of 100 points. Part A of the two-part exam will be scored on the basis of 40 – 70 points and Part B will be scored on the basis of 30 – 60 points.

An alternate exam time will be scheduled for students who have an unavoidable, documentable time conflict with an evening mid-term exam. Details will be announced well advance of each exam.

**Final Exam:** The common final exam is Friday, May 16, 7:00 – 9:00 AM. The final will cover the entire course and will be scored on the basis of 200 points. The final will be a one-part exam. You may have your calculator for the entire exam. However, most questions will require you to give a solution that doesn’t depend on a calculator.

Attendance at the final exam is required. (Don’t ask to take the final early or late!) If you have three or more final exams on the same day you may negotiate a time change with the instructors involved. If the parties involved cannot find a mutually agreeable time, the Registrar's Office indicates which exams must be rescheduled. If you have three exams on the same day, talk with instructors involved at least 3 weeks in advance. Unless you happen to be taking two calculus courses, you must take the MATH 160 final exam at the scheduled time.
Homework: Homework from the textbook will be assigned and scored regularly. There will usually be three or four homework assignments due each week. Each homework assignment will be scored on the basis of 10 points. Seven (7) points will be assigned for completeness (a serious, coherently presented attempt on every problem). Three (3) points will be assigned for correctness as follows. Three problems will be selected to be graded for correctness. Each one will be graded 0 or 1 point. To earn a score of 1, a solution must be essentially correct and clearly and completely presented. Missing homework will be scored 0 points. *Late homework will not be accepted.*

The top 80% of your scores on assigned homework will count for your final grade. Homework will count 75 points toward your final grade.

ALEKS: Many students say, “Calculus is easy; it’s algebra that’s hard.” To do calculus successfully, you must have a solid command of pre-calculus. The ALEKS component of MATH 160 is to help you “firm up” your skills with pre-calculus topics so you can learn calculus more easily. ALEKS is a web-based, artificially intelligent assessment and learning system. ALEKS uses adaptive questioning to quickly and accurately determine exactly what you know and don’t know in pre-calculus. ALEKS then instructs you on the pre-calculus topics you are most ready to learn. ALEKS provides one-on-one instruction, 24/7, from virtually any web-based computer. You should have ALEKS assessment scores of at least 70% before the first midterm and at least 80% before the second midterm. Your ALEKS scores will count 75 points toward your final grade.

Concept Quizzes: There will be several short Concept Quizzes designed to help you gauge your understanding of important concepts and your ability to communicate your understanding clearly. Midterm and Final Exams will include questions like those on the Concept Quizzes. Concept Quizzes will be graded by standards similar to those used to grade conceptual questions on exams. Concept Quizzes will count 75 points toward your final grade.

Missed Concept Quizzes can be made up only in the case of absence because of participation in official university activities, documentable illness, or other extenuating circumstances.

Calculator Labs: There will be several (six to eight) laboratory investigations that invite you to use your calculator to explore and develop a deeper understanding of concepts from calculus. A written report is required for each lab investigation. Lab investigations are to be completed outside of class. Lab reports will count 75 points toward final grade.

Grading Standards: The 800 points possible in this course are calculated as follows:

\[
\text{Point Total} = \text{Homework (75 pts)} + \text{ALEKS (75 pts)} + \text{Concept Quizzes (75 points)} + \text{Lab reports (75 pts)} + 3 \text{ Mid-term scores (300 pts)} + \text{Final exam score (200 pts)}
\]

You must earn a passing grade (D or above) on the final examination to get a grade above D in MATH 160. In other words, if your grade on the final exam grade is F, the best grade you can get in MATH 160 is D. If you earn a passing grade on the final exam (D or above), your final grade will be determined from your Point Total using a grading scale no more restrictive than the following:

| 90% – 100% | 720 – 800 | A | 55% – 60% | 440 – 479 | D |
| 80% – 89% | 640 – 719 | B | less than 55% | 0 – 439 | F |
| 60% – 79% | 480 – 639 | C | |

Plus/minus grades may be assigned in exceptional situations. A grade of incomplete (I) will be assigned only in extenuating circumstances (beyond the student's control and could not reasonably have been anticipated or avoided) and with approval of the Course Coordinator and the Undergraduate Director.

Repeat/Delete: Undergraduate students may repeat a course in which they have received an unsatisfactory grade with only the grade earned when the course is repeated counting toward the GPA. However, this option can be used in no more than three courses totaling no more than 10 credits. **If you are not succeeding in a course it is almost always better to W-drop than to use the Repeat/Delete option. (One of the few exceptions is when dropping the course would result in loss of financial aid.)** In cases where extenuating circumstances prevent you from successfully completing a course, an incomplete (I) grade might be a possibility. See the CSU General Catalog (available on line) for the University Repeat/Delete Policy. Do not hesitate to seek advice from your instructor, the Course Coordinator, or your Academic Adviser.
**Academic Appeals**: Concerns about the course or any of your instructor’s decisions that affect your participation in the course should first be discussed with the instructor. Issues that cannot be resolved with the instructor should be discussed with Prof. G. Dangelmayr, Mathematics Department Undergraduate Director. To see Prof. Dangelmayr, make an appointment in the Mathematics Department Office (Weber 101).

The University Policy on appeals of academic decisions as published under "Academic Rights and Responsibilities of Students" in the current CSU General Catalog and in the document "Student Rights and Responsibilities" available from the Office of the Vice President for Student Affairs applies in this course.

**Policy on Academic Honesty**: The University Policy on Academic Integrity (see CSU General Catalog) is enforced in this course. Misrepresenting someone else's work as your own and possessing unauthorized reference information in any form that could be helpful while taking an exam are examples of cheating. Students judged to have engaged in cheating may be assigned a reduced or failing grade for the assignment or the course and may be referred to the Office of Conflict Resolution & Student Conduct Services for additional disciplinary action.

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**MATH 160 Topic Outline & Schedule**  
**Spring Semester, 2008**

- **Week 1** 1/21 – 1/25  
  Ch 2 Limits and Continuity  
  Monday, 1/21, is a University Holiday

- **Week 2** 1/28 – 2/01  
  Ch 2 Limits and Continuity  
  Monday, 1/28. Last day to add MATH 160

- **Week 3** 2/04 – 2/08  
  Ch 2 Limits and Continuity  
  Wednesday, 2/06, last day to “free” drop

- **Week 4** 2/11 – 2/15  
  Chs 2 & 3 Tangents & Derivatives  
  Thursday 2/14, 5:15 - 7:00 PM.  
  First common midterm exam. Location tba.  
  Class will not meet Friday, 2/15.

- **Week 5** 2/18 – 2/22  
  Ch 3 Differentiation

- **Week 6** 2/25 – 2/29  
  Ch 3 Differentiation

- **Week 7** 3/03 – 3/07  
  Ch 3 & 4 Applications of Derivatives

- **Week 8** 3/10 – 3/14  
  Ch 4 Applications of Derivatives  
  Thursday 3/13, 5:15 - 7:00 PM.  
  Second common midterm exam. Location tba.  
  Class will not meet Friday, 3/14.

  3/15 – 3/23  
  Spring Break

- **Week 9** 3/24 – 3/28  
  Ch 4 Applications of Derivatives  
  Monday, 3/24, last day to W-drop

- **Week 10** 3/31 – 4/04  
  Ch 4 & 5 Antidifferentiation & Integration

- **Week 11** 4/07 – 4/11  
  Ch 5 Integration

- **Week 12** 4/14 – 4/18  
  Ch 5 Integration  
  Thurs. 4/17, 5:15 - 7:00 PM  
  Third common midterm exam. Location tba.  
  Class will not meet Friday, 4/18.

- **Week 13** 4/21 – 4/25  
  Ch 6 Applications of Integration  
  Check the final exam schedule. If you have three finals on Friday, 5/16, talk with your instructor about how to get one rescheduled.

- **Week 14** 4/28 – 5/02  
  Ch 6 Applications of Integration

- **Week 15** 5/05 – 5/09  
  Ch 6 Applications of Integration

- **Week 16** 5/12 – 5/16  
  Final Exam Week  
  Friday, 5/16, 7:00 – 9:00 AM  
  Common final exam. Location to be announced.
April 11, 2008

To whom it may concern,

I am pleased to support this proposal from Professor Ken Klopfenstein to study student performance in our first semester calculus course MATH CC 160 “Calculus for Physical Scientists I”. This is an essential pre-requisite course for many science and all engineering majors as it underpins so much of their later studies. As an entry-level course, incoming students have a wide range of backgrounds, preparation and abilities. We are fortunate to be able to teach most students in small sections, but there is still a large D, F, W rate for reasons which remain largely unknown, though a considerable folklore exists. Prof. Klopfenstein is attempting to isolate and identify the role of one of the “usual suspects”, namely weak pre-calculus skills. Some definitive answers for the significance of this weakness and effective means for moderating the effect these deficiencies would be a major step forward in calculus instruction. The technologies we have developed PACe center for online randomized testing and mastery-based instruction, make it credible that we can take the lessons learned in MATH CC 160 and apply them to other mathematics courses.

Yours sincerely,

Simon J. Tavener
Chair, Department of Mathematics