

Fall 2015

Analytic Geometry and Calculus I

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Ault, Shaun V. and Goel, Sudhir, "Analytic Geometry and Calculus I" (2015). *Mathematics Grants Collections*. Book 6.
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Grants Collection

Valdosta State University



UNIVERSITY SYSTEM
OF GEORGIA

Shaun Ault, Sudhir Goel

Analytic Geometry & Calculus I





Grants Collection

Affordable Learning Georgia Grants Collections are intended to provide faculty with the frameworks to quickly implement or revise the same materials as a Textbook Transformation Grants team, along with the aims and lessons learned from project teams during the implementation process.

Each collection contains the following materials:

- **Linked Syllabus**
 - The syllabus should provide the framework for both direct implementation of the grant team's selected and created materials and the adaptation/transformation of these materials.
- **Initial Proposal**
 - The initial proposal describes the grant project's aims in detail.
- **Final Report**
 - The final report describes the outcomes of the project and any lessons learned.



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Syllabus

MATH 2261

ANALYTIC GEOMETRY & CALCULUS I

Prerequisites and Required Materials

- Pre-requisites: MATH 1112 or MATH 1113, with a C or higher.
- Required Textbook: APEX Calculus, Version 3.0 (available online for **free**). We will also use supplementary workbooks for Algebra and Trigonometry review.
- Optional Calculator: TI-83/84 Plus graphing calculator, or equivalent.
- Required WeBWork Access: **Free** account (see WeBWork handout).
- BlazeView Access: Used for posting course handouts, news announcements, gradebook, calendar, etc.

Note: This section is a designated pilot section for VSU's No-Cost Calculus initiative (Affordable Learning Grant #64, proposal by Shaun Ault and Sudhir Goel). As such, there is no purchase required for a textbook. Textbook will be available online at <http://www.apexcalculus.com/>. If any student wishes to have a hardcopy version, the student must print it.

Course Description

- Introduction to limits, derivatives, integration, the fundamental theorem of calculus, and applications
- Student Learning Outcomes:
In this course the student will learn the methods and applications of differential calculus and the motivation for the integral calculus. Properly using the language and notation of calculus, students will analyze functions and solve applied problems. Upon completion of the course, the intent of the instructor is that the students will be able to:
 1. Compute limits of algebraic and transcendental functions.
 2. State, use, and interpret the definitions of continuity and the derivative in terms of limits.
 3. Formulate derivatives of algebraic and transcendental functions using the power, product, quotient, and chain rules.
 4. Analyze and construct graphs of functions by using and combining calculus and precalculus methods.
 5. Apply the derivative to calculate rates of change and solve applied optimization problems.
 6. Demonstrate how antidifferentiation and Riemann sums relate to the integral calculus.
 7. Use the Fundamental Theorem of Calculus and substitution to compute definite and indefinite integrals.

Schedule

All sections are from APEX Calculus unless otherwise indicated.

Monday	Tuesday	Wednesday	Thursday
8/17: Intro, Algebra Review (Functions)	8/18: Algebra Review (Functions and Graphing)	8/19: Trig Review (Trigonometric Functions)	8/20: Algebra / Trig Review (Transformations)
8/24: Algebra Review / (Exponentials) / Q.1 d	8/25: Algebra / Trig Review (Inverse Functions and Logarithms)	8/26: Recit. / Q.2 (Algebra / Trig)	8/27: 1.1
8/31: 1.2	9/1: 1.3	9/2: Recit. / Q.3 (1.1-3)	9/3: 1.4
9/7: No Classes	9/8: 1.5	9/9: 1.6	9/10: Recit. / Review
9/14: TEST 1 (Ch.1)	9/15: 2.1	9/16: 2.2	9/17: Recit. / Q.4 (2.1-2)
9/21: 2.3	9/22: 2.4	9/23: Recit. / Q.5 (2.3-4)	9/24: 2.5a
9/28: 2.5b	9/29: Recit. / Review	9/30: TEST 2 (2.1-5)	10/1: 2.6
10/5: 2.7	10/6: Recit. / Q.6 (2.6-7)	10/7: 3.1	10/8: 3.2
10/12: No Classes	10/13: No Classes	10/14: Recit. / Q.7 (3.1-2)	10/15: 3.3
10/19: 3.4	10/20: 3.5	10/21: Recit. / Rev.	10/22: TEST 3 (2.6-7, Ch. 3)
10/26: 4.1	10/27: 4.2	10/28: Recit. / Q.8 (4.1-2)	10/29: 4.3a
11/2: 4.3b	11/3: 4.4	11/4: Recit. / Q.9 (4.3-4)	11/5: 6.7
11/9: Recit. / Review	11/10: TEST 4 (Ch. 4, 6.7)	11/11: 5.1a	11/12: 5.1b
11/16: 5.2	11/17: Recit. / Q.10 (5.1-2)	11/18: 5.3a	11/19: 5.3b
11/23: 5.4a	11/24: 5.4b	11/25: No Classes	11/26: No Classes
11/30: Recit. / Q.11 (5.3-4)	12/1: 5.5	12/2: 6.1a	12/3: 6.1b
12/7: Final Review			

Links to No-cost Materials

1. APEX Calculus (version 3.0), by Gregory Hartman et al.

www.apexcalculus.com/downloads/

2. WeBWork library (specific to APEX Calculus). Available from within the (free) WeBWork system (see webwork.maa.org). Also available as a tgz file on OER commons:

<https://www.oercommons.org/authoring/11231-no-cost-calculus-using-apex-and-webwork>

3. Although we had originally planned to offer Algebra and Trigonometry Workbooks, we did not have enough time to finish them. Therefore no link will be provided here.

Initial Proposal

**Affordable Learning Georgia Textbook Transformation Grants
Round 2
Summer 2015, Fall 2015, Spring 2016
Proposal Form and Narrative**

Institution Name(s)	Valdosta State University				
Team Members (Name, Title, Department, Institutions if different, and email address for each)	Shaun V. Ault, Assistant Professor. svault@valdosta.edu Sudhir Goel, Professor. sgoel@valdosta.edu Department of Mathematics and Computer Science. Valdosta State University				
Sponsor, Title, Department, Institution	Greg Harrell, Department Head Department of Mathematics and Computer Science. Valdosta State University				
Course Names, Course Numbers and Semesters Offered (Summer 2015, Fall 2015, or Spring 2016)	Analytic Geometry & Calculus I, MATH 2261, Fall 2015 – Spring 2016.				
Average Number of Students Per Course Section	35	Number of Course Sections Affected by Implementation In Academic Year 2016	15	Total Number of Students Affected by Implementation In Academic Year 2016	525
Award Category (pick one)	<input checked="" type="checkbox"/> No-Cost-to-Students Learning Materials <input type="checkbox"/> OpenStax Textbooks <input type="checkbox"/> Course Pack Pilots <input type="checkbox"/> Transformations-at-Scale				

<p>List the original course materials for students (including title, whether optional or required, & cost for each item)</p>	<p>Required Textbook:</p> <p>Thomas, Weir, and Hass, <i>Thomas' Calculus: Early Transcendentals, Single Variable plus MyMathLab, 13ed.</i> Pearson.</p>	<p>Cost</p> <p>\$141.70 plus tax = \$151.62 / student</p> <p>Total Cost</p> <p>Up to \$151.62 x 525 = \$79,600.50</p>	
<p>Plan for Hosting Materials</p>	<p><input type="checkbox"/> <u>OpenStax CNX</u></p> <p><input checked="" type="checkbox"/> <u>D2L</u></p> <p><input type="checkbox"/> <u>LibGuides</u></p> <p><input type="checkbox"/> Other _____</p>		
<p>Projected Per Student Cost</p>	<p>\$0.00</p>	<p>Projected Per Student Savings (%)</p>	<p>100%</p>

1. PROJECT GOALS

The main focus of this project is to prove the feasibility and effectiveness of replacing the current high-cost (but high quality) required textbook and associated online resources for Math 2261 (Calculus I) by high-quality no-cost instructional materials, including a free electronic textbook, supplemental handouts/worksheets that are either freely available or created specifically by us for this course, and an optional computerized homework system, such as the open-source, freely-available WeBWork system, that could replace MyMathLab. It is important to identify those no-cost options that are not lower in quality or effectiveness than the current (high-cost) options, and so time is needed to evaluate and/or create such materials.

Students in the Calculus sequence currently must purchase a textbook that costs over \$150, which is burdensome, especially to low-income and non-traditional students. Even students who receive financial aid for textbook purchases sometimes have to wait until the second week of classes before the aid becomes available. Although the textbook may be used by students in subsequent Calculus II (Math 2262) and Calculus III (Math 2263) courses, thus spreading the cost out over three semesters, only a small fraction of Calculus I students do carry on through the entire sequence. In particular, Biology majors do not typically take Calculus II.

The USG's Affordable Learning Georgia initiative provides a unique opportunity for us to explore options and implement them in pilot courses of Math 2261 during Fall 2015 and Spring 2016, which could lead to implementation of the no-cost model throughout all 15 sections of Math 2261 per year that are offered starting in Fall 2016. After full scale implementation, this project will reduce student textbook costs to \$0.00 for students of Math 2261, a course that has been identified as one of the Top 50 USG Lower-Division Courses.

As an added benefit, the supplements that we develop will be tailor-made for the students of VSU. Many of our students enter Calculus without an adequate background in Algebra or Trigonometry. They may have poorly-developed study skills on top of a general fear of math. We plan to include materials that will directly address such shortfalls.

1.1 TRANSFORMATION ACTION PLAN

There are two phases planned. In the first phase, which will occur during Summer 2015, we will explore many different no-cost resources, falling under three main categories (there may be overlap): Textbook, Supplements, and Homework Materials.

We will evaluate the electronically-available textbook options, including those on the Approved Textbook list from the American Institute of Mathematics (<http://aimath.org/textbooks/approved-textbooks/>). Textbooks will be evaluated in comparison to the current text, Thomas' Calculus. Only the highest-quality text that is also the best fit for the students at VSU will be chosen.

Supplements include handouts, worksheets, and review materials that could be helpful to students of Calculus. Dr. Ault already has put together a number of such supplements for use in his existing courses, while Dr. Goel has experience writing extensive practice materials for College Algebra. Other supplements will be located from free online sources or developed by us during Summer 2015.

Finally, an important component of any math class is the homework. Some instructors will prefer to assign problems from the textbook, while others might prefer using an online homework system, and there are others who prefer to assign and grade custom-made turn-in homework problems. Some textbooks we consider may include sufficient homework exercises, while others may be lacking. Further homework problems with fully-worked solutions will be written during Summer 2015, if need be. As for an online homework system, WeBWork is the best option, as it is open-source and freely-available (<http://webwork.maa.org/>). Moreover, Dr. Ault has experience writing custom homework problems with solutions for a version of WebWork used at The Ohio State University.

The second phase is a trial run implementation of the new no-cost materials. Dr. Ault is scheduled to teach two sections of Math 2261 in Fall 2015. In order to effectively evaluate the impact of the changes, one course will be taught using the usual materials (Thomas' Calculus textbook with MyMathLab access), while the other will be taught using the selected no-cost resources. Both courses will cover the same topics in the same amounts of lecture time. In order to best evaluate the changes, Dr. Ault plans to administer the same quizzes, tests, and final exam to both sections. In addition, Dr. Goel and one other Calculus instructor, not associated with this grant, will also run pilot no-cost sections of Math 2261 in the Fall.

The syllabus and lecture schedule for the altered course and all supplementary materials will be developed during Summer 2015. No further course redesign is necessary, as the topics discussed in lecture will remain the same. All materials will be easily accessible to students online through BlazeView (D2L) and accessible to instructors via the shared network "V drive". Students who wish to have a "hard copy" of the textbook will be

responsible for printing it themselves. In addition, all of our materials will be made available to the public (**open access**) by placing the documents on Dr. Ault's website,

<https://valdosta.academia.edu/ShawnAult>

which is freely accessible to anyone with an internet connection.

1.2 QUANTITATIVE AND QUALITATIVE MEASURES

As outlined above, there will be multiple pilot courses taught using a no-cost format (NC) in Fall 2016. Each pilot will be evaluated in comparison to control courses taught using the current resources (C). As part of this study, we will measure quantitative metrics such as the **effectiveness** of NC (do students achieve similar or better levels of mastery of Calculus?), **retention rates** (are students less likely to drop the course?), and qualitative metrics, such as **perception** (are students less stressed by the NC course, or do they have a more positive opinion of the course or instructor, etc).

- Effectiveness will be assessed by comparing the mean scores on quizzes, tests, and final exam of students in NC courses with students in the C courses. The validity of the data is ensured by the fact that the quizzes, tests, and final exam will be similar to those given in the past in this course and hence are known to accurately assess Calculus understanding.
- Retention rates will be gathered. The rate for NC courses will be compared not only with that of C courses, but also with the rates for past (recent) sections of Calculus I.
- Student surveys will be administered at various points in the semester to the students of both NC and C courses in order to measure the qualitative impact of using no-cost versus typical course resources.

1.3 TIMELINE

February 2nd : Project initiation meeting (kick-off). Dr. Ault will attend.

May 11th – 22nd

- Begin reviewing and evaluating no-cost textbooks for Calculus, starting with the AIM Approved Textbook list.
- Set up WeBWorK on a VSU server.

May 25th – June 5th

- Once a textbook has been settled on, determine if there are sufficient homework exercises. If not, begin compiling a comprehensive list of exercises for each section.
- Choose WeBWorK problems for each Calculus topic, and begin writing new problems if needed.

June 8th – 31st

- Finish writing homework exercises and/or WeBWorK problems.
- Identify helpful supplementary handouts and worksheets from existing sources.
- Write additional supplementary handouts and worksheets to fill any remaining needs in the course.

August 3rd – 14th

- Modify the syllabus for the section that will implement no-cost materials.
- Place all electronic materials, including the textbook, on the BlazeView site for the course.
- Write surveys for students to collect qualitative data about both courses.
- Mid-implementation project status report.

August 17th – December 11th

- Fall semester. One course is taught with no-cost materials, while a sister course is taught using Thomas' Calculus with MyMathLab
- Administer an entrance survey, a midterm survey, and an exit survey.

December 14th – 18th

- Prepare final report that will be disseminated to appropriate recipients.

Spring 2016: The Department of Math/CS will discuss moving forward with the no-cost format for all Math 2261 sections starting Fall 2016.

1.4 BUDGET

Summer pay for Dr. Ault: \$5000 in salary and benefits.

Summer pay for Dr. Goel: \$5000 in salary and benefits.

Travel funds: \$800 for travel to attend the required project initiation meeting (kick-off) on February 2nd, 2015. Dr. Ault will attend.

Total: \$10800.

1.5 SUSTAINABILITY PLAN

After the pilot no-cost course has been evaluated for effectiveness, retention, and positive perceptions, and if the Department of Math/CS agrees to move forward on wider implementation, we will facilitate the transition of all sections of Math 2261 to a no-cost format starting in Fall 2016. This will be an easy transition, as all of the materials will have been developed by the beginning of Fall 2015 – it would be as easy as a textbook change. From that point onward, the courses do not require extra maintenance.

1.6 REFERENCES & ATTACHMENTS

- *Letters of Reference:*
 - *Dr. Greg Harrell*

1.7 PROPOSAL SUBMISSION: ALL PROPOSAL DOCUMENTS, REFERENCES, AND ATTACHMENTS MUST BE SUBMITTED IN A SINGLE EMAIL TO ALG@GATECH.EDU.

DEADLINE FOR CATEGORIES 1-3: 5:00 PM, NOVEMBER 30, 2014

DEADLINE FOR CATEGORY 4: 5:00 PM, DECEMBER 8, 2014

Final Report

Affordable Learning Georgia Textbook Transformation Grants

Final Report

Date: 12/15/2015

Grant Number: 72

Institution Name(s): Valdosta State University

Team Members (Name, Title, Department, Institutions if different, and email address for each):

- **Dr. Shaun V. Ault, Asst. Professor, Department of Mathematics and Computer Science, svault@valdosta.edu**
- **Dr. Sudhir Goel, Professor, Department of Mathematics and Computer Science, sgoel@valdosta.edu**

Project Lead: Ault

Course Name(s) and Course Numbers: MATH-2261 – Analytic Geometry & Calculus I

Semester Project Began: Summer 2015

Semester(s) of Implementation: Fall 2015

Average Number of Students Per Course Section: 26.5

Number of Course Sections Affected by Implementation: 2

Total Number of Students Affected by Implementation: 53

1. Narrative

Our goal was to develop and implement a no-cost option for Calculus (specifically, MATH-2261, Analytic Geometry & Calculus I). Traditionally, Calculus students are expected to purchase a textbook that costs over \$150, and get access to an online homework system which alone costs about \$90. While certain bundle deals exist to combine the two resources into one discounted purchase, the materials are nevertheless quite expensive. In my experience teaching Calculus at VSU (since Fall 2012), I have heard from many students who said they had to wait until the 2nd or 3rd week, or even later, before they could afford to purchase the required materials. Meanwhile, the lecture is based entirely upon the textbook and homework system, so student who did not have those materials were at a distinct disadvantage right from the start.

Of course you get what you pay for, as they say. The expensive book and homework system are quite effective at communicating the mathematical concepts to students. Any

replacement materials had to meet stringent quality measures in order to benefit the students. Furthermore, the chosen materials had to be flexible enough to permit a wide range of instructors' teaching styles. To that end, our grant proposal consisted of the following: finding a high-quality no-cost textbook covering at least the departmental course objectives for MATH-2261 and containing enough textbook exercises so that instructors could choose not to use an online homework system if desired; implementing a no-cost online homework system to go with the textbook; developing or locating additional no-cost resources to help our students succeed in Calculus.

After reviewing many possible free textbooks a short-list of three possibilities emerged. A careful reading of each textbook led towards the final choice of APEX Calculus, by Gregory Hartman et al. The textbook was found to have an adequate number of varied exercises at the end of each section. Sections are arranged in roughly the same order as in our current traditional textbook, Thomas Calculus, although APEX lacks a preliminary chapter on algebra, trigonometry, and pre-calculus concepts. This deficiency was addressed by providing supplementary materials.

For an online homework system, the clear choice was WeBWork, which is maintained by the Mathematical Association of America (MAA). Numerous institutions across the country have been using WeBWork for years to great success, including at The Ohio State University, where Dr. Ault gained valuable experience as an Assistant WeBWork administrator while pursuing his graduate degree. There are already free problem libraries available, and we initially thought that these libraries could be sufficient for building homework sets corresponding to the sections of APEX Calculus, however we eventually decided to create a new problem library specific to APEX. Ault created on a library of 365 problems, modeled from the end-of-section problems in the text. We worked closely with VSU's IT department to set up a WeBWork server on campus, which can be accessed at: <https://webwork01.valdosta.edu/webwork2>.

Finally, we had planned to write workbooks to help students with pre-calculus material. Dr. Goel has completed the content for an Algebra workbook and a Trigonometry workbook, but these two items still need editing and formatting before we can use them in the course. We simply ran out of time.

The no-cost materials were implemented in two pilot courses in Fall 2015. Dr. Ault taught one using WeBWork exclusively for homework, and Dr. Goel taught another using the textbook problems exclusively. Aside from using the no-cost materials, there was not a huge impact on the way either of us taught the course – and this was the desired outcome. In order to eventually make a smooth transition to no-cost across all sections of Calculus, it is important that instructors do not have to re-learn how to teach the subject. A textbook change is traumatic enough, usually necessitating writing a new set of lecture notes, quizzes, tests, etc., so our aim for the no-cost material is that it should be no more work than a textbook change.

On the other hand, we are pleased to report a positive change in student perceptions about the course, along with no appreciable negative impact on grades, DFW rates, or preparedness for Calculus II (as measured by meeting course objectives for Calculus I). Our data below substantiates this claim.

There are not very many things we would do differently, except to give ourselves more time and a less ambitious writing schedule for the supplementary materials. Now that we understand the number of hours required to write WeBWork problems and supplementary workbooks, we can budget our time better for those items in the future.

2. Quotes

Student reactions were somewhat mixed between appreciating the fact that the materials were free to complaining that the problems were too hard or something was lacking or hard to use in the homework program compared to other programs. These are issues that could be addressed by changing the homework problems and putting in links to worked-out examples.

- “The fact that the book + homework program are free is amazing. The fact that they are free does not subtract from the overall class experience because the lectures in class cover everything. Two complaints that I do have though are the text book not having a direct link in WeBWork and the lack of examples in WeBWork.”
- “The free materials were much better to use. I was more willing to go on the textbook or WeBWork and play around with the system.”
- “Sometimes I miss having an actual textbook in front of me, but do not miss the cost of the textbook.”
- “Some of the WeBWork problems are too difficult; however once I figure them out I have learned something new.”
- “In my opinion WeBWork would be better if there were examples given underneath each problem like of MyMathLab. Also I thought it was helpful how MyMathLab walked you through the answers that you got wrong.”

3. Quantitative and Qualitative Measures

3a. Overall Measurements

Student Opinion of Materials

Was the overall student opinion about the materials used in the course positive, neutral, or negative?

Total number of students affected in this project: 53

- Positive: 65 % of 26 number of respondents
- Neutral: 27 % of 26 number of respondents

- Negative: 8 % of 26 number of respondents

Student Learning Outcomes and Grades

Was the overall comparative impact on student performance in terms of learning outcomes and grades in the semester(s) of implementation over previous semesters positive, neutral, or negative?

Choose One:

- Positive: Higher performance outcomes measured over previous semester(s)
- Neutral: Same performance outcomes over previous semester(s)
- Negative: Lower performance outcomes over previous semester(s)

Student Drop/Fail/Withdraw (DFW) Rates

Was the overall comparative impact on Drop/Fail/Withdraw (DFW) rates in the semester(s) of implementation over previous semesters positive, neutral, or negative?

Drop/Fail/Withdraw Rate:

41.5 % of students, out of a total 53 students affected, dropped/failed/withdrew from the course in the final semester of implementation.

Choose One:

- Positive: This is a lower percentage of students with D/F/W than previous semester(s)
- Neutral: This is the same percentage of students with D/F/W than previous semester(s)
- Negative: This is a higher percentage of students with D/F/W than previous semester(s)

3b. Narrative

As stated in our grant proposal, the primary metric we were striving for is that students do *no worse* in the no-cost course than in the current traditional course. In terms of retention, DFW rate, course perceptions, meeting course objectives, and preparedness for subsequent math courses, we believe we have succeeded. Thus, the indication of “Neutral” in the questions above concerning grades, objectives, and DFW rates meets our own expectations for the project. While the data show an improvement in DFW rates and course medians, the delta values are not large enough to claim statistical significance. What follows is a more detailed assessment of the measures.

- I. DFW rates. There seemed to be a large difference (-11%) in DFW rates when comparing to the same course taught using traditional materials (same instructor and semester).

While this is quite encouraging (less students DFW in the no-cost course), other co-factors cannot be ruled out.

- II. Median course scores. We found no significant change.
- III. Student success in learning objectives (measured by specific questions on the final exam, which was administered to one no-cost and one traditional section). We found no significant change.
- IV. Survey data. The majority of students had positive opinions of all the free materials (see accompanying spreadsheet).

There are sometimes wide differences in overall student performance from one section to the next, even if taught in the same semester by the same instructor. For this reason, we are cautious when attempting to conclude anything definite about the significance of our data. The best conclusion we can reach is that the no-cost option is no worse than traditional methods, and so there is little reason not to consider adopting no-cost for all sections going forward.

4. Sustainability Plan

In the short term, 5 more sections of no-cost Calculus will be offered in Spring 2016. Based on the data available, the MATH-2261 committee will vote on transitioning all sections of Calculus I to no-cost starting in Fall 2016. Dr. Ault will take on the role of WeBWorK Administrator and help to coordinate other aspects of no-cost Calculus as well. A common departmental final exam is currently being developed. Further updates to no-cost materials will be handled by instructors as needed.

5. Future Plans

- This project has given us a greater perspective on what open-access resources actually exist already. We were pleasantly surprised to have found such a high-quality free textbook relatively quickly. Dr. Ault plans to use his experiences on this grant to continue developing no-cost materials for the other courses in the Calculus sequence, 2262 and 2263, hopefully with the support of another ALG grant or other funding source.
- Dr. Ault has submitted a proposal to present at the USG Teaching and Learning Conference (April 13-14, 2016). Additionally, we plan to present a Teaching Colloquium here in the VSU Math Department.

6. Description of Photograph

- Dr. Shaun Ault, team lead, subject matter expert, question bank author and instructor of record for MATH-2261-D; Dr. Sudhir Goel (*not pictured due to health issues*), subject matter expert, workbook author and instructor of record for MATH-2261-E.