DIABLO VALLEY COLLEGE
Office of the President

DATE: October 2024

TO: Sabbatical Leave Committee

FROM: Susan Lamb

SUBJECT: Sabbatical Leave Report – Lindsey Lang

The following objectives and corresponding evidence were proposed in Lindsey Lang's sabbatical leave application:

Objective: Create a complete mastery-based system, including objectives, assessments and reassessments, course grading structure, and record-keeping system for Math 192: Analytic Geometry and Calculus I. Present information in FLEX workshop.

Evidence: A set of 20 - 35 clearly-defined, individually assessable learning outcomes for the course based on the student learning outcomes of record.

A set of assessment questions for each of the created outcomes, with a minimum of 150 individual assessment questions total.

A clearly-defined course structure for how final grades are calculated based on the course activities, assignments, and assessments. This structure will address how many outcomes need to be mastered for each final course grade, as well as how homework and the final exam factor into the course grade.

A system that tracks student achievement of course outcomes, a mechanism for tracking reassessment of outcomes, a structure that records student progress toward final grades that can be shared with students, and student facing documentation describing the structure and policies of course grading in the mastery-based system.

A workshop that presents the drawbacks of tradition points-based systems, the benefits of mastery-based systems, different implementations of mastery-based systems in STEM classrooms, steps to convert a course to mastery-based grading, and resources for further information.

I have reviewed the submitted evidence and attest she has met the specifications as outlined in her sabbatical application.

SECTION V. SABBATICAL LEAVE APPLICATION

Lindsey Lang

Name (Open Print Preview to have your name populate throughout the form)

Feb 10, 2023

Date

Diablo Valley College

College

Fall 2023

Sabbatical leave period requested

Mathematics

Teaching field(s)

17

Years of service in CCCCD

Have you had previous Sabbaticals? If "yes" give time period(s) and activity (activities).

No

Indicate type of Sabbatical program (see United Faculty Agreement, Section 12.5.6) If program can be categorized by more than one type, check where applicable.

☐ Institutional study (complete Form A)
☐ Travel (complete Form B
☒ Professional Study and/or Creative Study (complete Form C)

GENERAL SUMMARY OF SABBATICAL PROGRAM

(GIVE A 100-WORD MAXIMUM STATEMENT)

For my one semester sabbatical, I will convert my Calculus I course (Math 192) to an entirely mastery-based course, including all assignments and assessments grading based solely on demonstration of mastery by students on the standard(s) in the assignment or assessment. I will research details of mastery-based implementations in STEM classrooms, create a FLEX workshop presentation on mastery-based grading systems, and create a complete mastery-based course with all structures and documentation that any Math 192 instructor could use.

Lindsey Lang

Name

VALUE TO EDUCATIONAL PROGRAM

(The Sabbatical Leave Committee will utilize this information as the basis for scoring Rubrics 1, 2, 3 and 4)

Describe how the proposed sabbatical will benefit the educational program. In particular:

1. *How will it benefit students, programs, or staff/colleagues?*

The vast majority of STEM courses, particularly in math, are structured on a points-based system. Students are given points on assignments, quizzes, exams, and possibly other categories including projects or discussions. Instructors determine how many points each problem is worth, and partial credit (points less than the full point value of a problem) is generally awarded for solutions to problems that are not completely correct. Final course grades are usually calculated using weighted averages for various categories of work, for example homework, quizzes, exams, project, final exam, etc.

There are many drawbacks to this traditional points-based system. There are often factors that do not measure students' learning and achievement of course outcomes that are included in scores, including whether an assignment was submitted on time or formatted in a requested manner. As a result, final course grades often do not accurately reflect whether students have attained individual learning outcomes; at best they reflect the overall degree to which students achieved the outcomes in general. Research documents how the partial-credit point system turns grades into a game, the object of which is to maximize points with the minimum amount of effort rather than a focus on learning and understanding the material (Benson, 2006; Nathan, 2005, Singleton-Jackson, Jackson, & Reinhardt, 2010). A grade of zero on one single assignment or assessment can have a catastrophic effect on a student's overall grade and morale. Moreover, the point-based system does not typically account for growth in student learning and understanding over the span of the term; rather, this system prioritizes formative assessments in the form of high stakes exams that cause stress and anxiety for students and offers no opportunity to earn points for increased mastery of exam topics after these assessments take place. In addition, research shows that students tend to ignore instructor feedback on points-driven assignments and assessments (Butler & Nisan, 1986). The student is losing valuable insight on how to improve their understanding by focusing on the points and ignoring the feedback, and the instructor is essentially wasting their time providing detailed feedback during the grading process if they also assign a numerical score. Points-based systems translate to an overall course percentage score out of 100, which is a very granular system allowing close to 70 different levels of failure and only 30 levels of success – are there really these many levels of demonstrated learning in the course and how is failure more finely distinguished than success?

Conversely, a mastery-based system awards credit, not points, when a student demonstrates achievement of course outcomes. Assessments and assignments are graded on a two- or three-tier rubric: successful or not yet successful, with a possible third-tier allowing for revision. A student who does not earn credit for demonstrating mastery on an outcome during an assessment is given the opportunity to reassess those outcomes throughout the term using new assessment questions that assess the same outcomes. This system allows for a more flexible timeline of student learning and motivates students to master concepts rather than maximize points. Students are not punished for having a poor showing on exam day; rather, they are rewarded for following up on feedback and being persistent in working towards demonstrating their achievement of course outcomes. There are various ways to calculate the final course grade in a mastery-based course, but that calculation is always based on the number of outcomes with demonstrated mastery. Thus, a mastery-based system upholds high academic standards while motivating students to learn and excel. It also reduces student stress around high-stakes exams and improves student and instructor relations by eliminating the argument over points. A critical aspect of a mastery-based system is feedback. With mastery-based grading, instructors provide detailed feedback on unsuccessful mastery attempts. Students then use that feedback to investigate their errors and improve their learning before they attempt to reassess an outcome. The focus of these assessments becomes learning and mastering, rather than winning the points game. In addition, this cycle of feedback and improvement encourages and normalizes help-seeking behavior, which has positive ripple effects in students' entire academic career.

Converting my entry-level Calculus course to an entirely mastery-based course will benefit teachers and students by reducing conflict and stress associated with traditional grading and by focusing the students on learning rather than playing the points game. Moreover, with the new law AB 1705 coming into effect, all new incoming STEM students may be required to start in Calculus (as opposed to the AB 705 model of students starting in Trigonometry or Pre-Calculus). Now more than ever it will be critically important that we focus our students on mastery of course content as the method of passing the course, not winning the points game.

2. *How will it enhance and/or improve your background and professional competence?*

While the mathematics of Calculus may not have changed in several hundred years, best practices in education continue to evolve. I strive to stay updated on educational research related to all aspects of my career, and I have long felt that the traditional points-based system used to grade students is inadequate. In the past several years, I have embarked on learning about other grading methods and systems on my own time, including reading books, papers, and blogs written on the topic and taking an online class from College Bridge last spring to learn more about how to convert my classes to a mastery-system. This initial exploration has inspired me to discover more about how others have been able to implement this system, specifically in the area of mathematics and Calculus. There are many different versions of mastery-based systems in practice, and this sabbatical will allow me the time to research those examples in my field to get a sense of how to best structure my mastery-based Math 192 course. It will also provide me with an opportunity to learn enough to become a source of information and guidance for my colleagues about mastery-based systems, which can begin with creating a thorough presentation of my research during the sabbatical.

AB705 and AB1705 are two pieces of legislation that have radically shifted the way that mathematics can be offered in community colleges in California. We have eliminated pre-transfer level math courses, and we may be on the way to having to lift prerequisite courses for Calculus, depending on what data the Chancellor's Office requests to evaluate their effectiveness. It has never been a more critical time for math instructors to evaluate how their class is structured and what the focus of the course truly is. By taking the time to build an entirely mastery-based Calculus course, I will be able to find that focus, to distill the course content to its essentials and build everything else in the course around the mastery of those essentials, eliminating the many distractions of a traditional system that de-motivate both students and teachers like high-stakes exams and power struggles over points. Instead, I will be able to finally build a culture in my classroom where learning is the reward and making mistakes and seeking help are critical parts of the learning process. I have attempted to do achieve these goals for a very long time through classroom activities and workshops, but when the underlying system by which the students will be ultimately graded perpetuates "the game", I will always fall short.

3. *How will it relate to your ongoing professional assignment?*

I teach Math 192 on a regular basis, so this project would relate to my teaching assignment in almost every semester. I also plan to share my resources, materials, process, and ideas with the math department through a FLEX workshop, so it will function as a pedagogical reference point for math instructors at DVC. I'll also be continuing to examine my disaggregated course data (retention and success), so over time I can compare my data in a points-based system to a mastery-based system and note any significant changes that may occur, particularly around equity gaps that tend to exist in all math courses.

4. *How are the breadth and depth of the project appropriate for the sabbatical leave rather than the regular teaching year?*

Converting a course entirely to a mastery-based system involves a great deal of work. I was motivated to embark on one step of the process in Fall 2022 in my Math 192 course, changing only how I graded quizzes and exams to a mastery-rubric: Successful (3 points), Needs Revision (2 points), New Attempt Required (1 point). This simple change required me to also dive into the process of creating reassessment questions and tracking reassessment attempts for students. The experience did focus the course on learning over points more than I have ever been able to do before and was extremely rewarding for both myself and my students. The experiment was also eye-opening for me; I realized that I could not implement all of the pieces at one time, due to the time-commitment necessary to do so. I was still using points and weighted averages to compute final course grades. I did not have an efficient system to track reassessments; instead, I fumbled through with a rather tedious system that taught me what not to do. I struggled to find the time to create mutliple versions of reassessment questions that were of similar difficulty and breadth as the original assessment questions - sometimes needing six to seven versions of one conceptually rich question. I felt overwhelmed by the daunting task of putting together all of the pieces that I would need to do in order to truly implement a mastery-system for the entire course. This sabbatical will allow me the ability to put all of the pieces together at once, so that I can complete the conversion with the thought and consideration it deserves, rather than in a piecemeal, time constrained manner.

Below, I will outline the tasks that are required for me to fully convert my Math 192 course to a mastery-based system. In part C, I have a clear breakdown of my time for each step of this process during my sabbatical.

1) Research mastery-grading implementations in mathematics and STEM classrooms.

As mentioned in question 2, I have done some introductory research about mastery-grading, how to convert a course, and various implementations used in different disciplines already. I feel that I have enough knowledge at this point to embark upon the journey of converting a course, and that I understand the steps needed to do so. However, I still want to learn more about specific implementations. I will seek out examples of college-level Calculus I courses and examine the structural details of the course, from the list of outcomes to the final grading structure and the methods of record-keeping (all of which are listed in the tasks below).

2) Create a set of clearly-defined, demonstratable learning outcomes for the course.

The student learning outcomes on the course outline of record guide the course curriculum and content. However, these official outcomes are general and contain multiple concepts or applications within each one; they are too broad in their current form to serve as the outcomes that provide the assessable structure of a mastery-based system. I will need to deconstruct the course SLOs into a set of between 20 – 35 individually assessable outcomes that are action-based, comprehensive, measurable, result in evidence of learning, and are bound to specific and important concepts. As I move through the other tasks, this initial list will continue to be revised and refined.

3) Create assessments and reassessments for each outcome.

Students will be given credit for demonstrating evidence of achieving each outcome in a classroom assessment setting, and when achievement is not demonstrated, students are given opportunities for reassessment. Depending on the final course grading structure (see step 5), an outcome may need to be demonstrated more than once during the semester. The majority of the assessment questions will be typical Calculus problems, including those that require conceptual explanation rather than quantitative analysis. If there are roughly 30 outcomes and I assume half of them need to be achieved twice, then I have roughly 45 assessment questions that serve as initial assessments - the first opportunity for students to demonstrate mastery. I then must factor in reassessments, which will require me to create multiple new problems of similar caliber on the same outcomes; these will not be the same problems with new numbers. Earlier course outcomes will require quite a few reassessment versions, since students will have more opportunities to take these reassessments. If I average 4 additional versions per original assessment question, that comes to roughly 180 reassessment questions that need to be created.

4) Research and design a course grading structure based on mastery to determine final grades in the course.

There are many examples of a final course grading structure based on mastery grading. I have already read and researched some examples of these structures in a College Bridge course on Standards Based Grading that I took last spring, as well as in the book Specifications Grading by Linda B. Nilson and the online blog Grading for Growth (gradingforgrowth.com). Some structures simply calculate the percentage of course outcomes mastered to determine the final grade, while others create "bundles" of outcomes achieved with other course tasks like homework reports or projects to create a list of requirements (sometimes called specifications) for each final course grade. Some structures may also bundle a group of outcomes that must be demonstrated together at the same time in a gateway assessment. For example, a Foundations Assessment towards the middle of the unit may assess six fundamental outcomes that students need to master before learning the next course outcomes. Students could be required to reassess the entire Foundations Assessment until at least 5 of 6 outcomes are successfully mastered on the same attempt, rather than reassess each outcome individually. Weekly homework is an essential part of learning Calculus, and how to incorporate credit for thoughtfully working through homework problems successfully is an aspect of mastery-grading systems that I need to explore more. I plan to continue to research specific examples used in college level math courses, specifically Calculus when available, in order to determine how I would like to determine final course grades, and then outline that structure in clear detail. This task will also require determining how to setup a final course gradebook, whether in Canvas or another system, that can track and communicate progress toward a final course grade to the students. It will also require producing clear documents that will be provided to students to describe the grading system.

5) Research and design a structure of assessments and reassessments that are manageable for the instructor and beneficial for the students.

As discussed in question 1, reassessments are a critical enabler of the mastery grading feedback loop: they give students the chance to learn from their mistakes and to show that they've improved their understanding. They also serve to reduce test anxiety and increase flexibility for the students' learning process. However, it is important that reassessment opportunities are not unlimited so the instructor is not overwhelmed with grading them and so students have time to complete the necessary work between attempts. To that end, I will plan an in-class assessment schedule that allows for timely initial attempts to demonstrate outcomes, without overwhelming the instructor workload. Students may also wish to reassess previously unachieved outcomes during student hours or other times outside of class, so I will also need to plan appropriate policies to accommodate students to do so. This task will also require creating an efficient and effective method of tracking standards' achievement and assessment attempts for the students. Traditional gradebooks are set-up to record scores on assignments and tests, not mastery of outcomes. Reassessments increase the complexity of tracking, as I will need to not only record when an outcome is mastered, but also when it was previously attempted and which version of the assessment was attempted. My own experiment in Fall 2022 taught me that this task is critically important.

Lindsey Lang

Name

PROPOSED OBJECTIVES AND EVIDENCE OF COMPLETION

(The Sabbatical Leave Committee will utilize this information as the basis for scoring Rubrics 5 and 6). Note that Rubric 6 regarding the "Proposed Evidence of Completion" is weighted twice that of all other rubrics.

Identify specific objectives and describe in detail the evidence that will accompany your report, which indicates that you have met each objective. The product of your approved sabbatical leave program will be subject to review by the Sabbatical Leave Committee at the time of making your final report. Examples follow:

Institutional study
Objective: *9 units of graduate level history courses as indicated on Form A will be taken at ... University.*
Evidence: *(Here you would describe the transcripts, class notes, exams, class projects, etc., you would submit as evidence of completing these units.)*

Travel
Objective: *Travel to archeological zones in Central America.*
Evidence: *(Here you would describe exactly what you plan to submit to document your sabbatical leave travel. You should specify the kinds of things you will present, like journals, artifacts, and slides, and you should give the committee an idea of the extent of the evidence by specifying the minimum number of slides, pages in a journal, number of museums, etc. If you so state, you must provide tangible evidence in your final sabbatical leave report that you have, in fact, written the minimum number of pages you proposed, visited the minimum number of archaeological zones you proposed, etc.*

Professional study and/or creative study
Objective: *Compose a musical score or write a textbook.*
Evidence: *(Here you would clearly indicate the scope of the project, including the minimum number of pages you plan to write, approximate length, an outline of the contents, description of the complexity, etc.)*

The Committee will rely on the information you provide in the evidence section to determine if you have met the contractual obligation of the leave.

Lindsey Lang

Name

INSTITUTIONAL STUDY
Form A

Name of Institution	*Place of Institution*

Period of Attendance	**UNDERGRADUATE LEVEL**	**GRADUATE LEVEL**
	☐ Semester units to be attempted* ☐ Quarter Units to be attempted **(Minimum 12 semester units)* **(Minimum 18 quarter units)* **Neither continuing education units (CEUs) nor courses taken from unaccredited institutions will be considered as Institutional Study. Please see Professional Study Form C.*	☐ Semester units to be attempted* ☐ Quarter units to be attempted **(Minimum 9 semester units)* **(Minimum 13.5 quarter units)* **Neither continuing education units (CEUs) nor courses taken from unaccredited institutions will be considered as Institutional Study. Please see Professional Study Form C.*

Accepted for Admission:

☐ Yes ☐ No ☐ Other

If "Yes," attach evidence of admission.
If "Other," explain:

List courses and unit value from the institution's catalogue. In case your choice of courses is not available, please indicate substitutions. (The Sabbatical Leave Committee will utilize this information as the basis for scoring Rubric 7. Be sure that the scope of your studies is clearly defined.)
** A full load is considered to be 12 semester units of undergraduate work or 18 undergraduate quarter units, or 9 semester units of graduate work or 13.5 quarter units at an accredited college/university.*

Lindsey Lang

Name

TRAVEL **Form B** **Plan: Itinerary** *(The Sabbatical Leave Committee will utilize this information as the basis for scoring Rubric 7. Be sure that the purpose, duration, and schedule of your travel are clearly delineated.)*		
Place	**Duration of Visit**	**Purpose**

Lindsey Lang

Name

PROFESSIONAL STUDY AND/OR CREATIVE STUDY
Form C

(The Sabbatical Leave Committee will utilize this information as the basis for scoring Rubric 7. Units completed at any unaccredited and/or international institutions will not be considered. Be sure the kind and scope of your study methods, resources, and activities are clearly delineated. Include an estimate of the time that will be spent engaged in various activities.)

Objective: Create a complete mastery-based system, including objectives, assessments and reassessments, course grading structure, and record-keeping system for Math 192: Analytic Geometry and Calculus I.

Evidence: I have outlined the steps to create this mastery-based course in question 4 above. Here is my proposed weekly schedule:

Each week will constitute approximately 40 hours of research, writing (outcomes, assessments), designing and creating systems, structures, and documents to communicate those systems.

Week 1 - 4: Research mastery-grading implementations in mathematics classrooms and create a FLEX presentation. See step 1 of question 4. This research will build on the work that I have done already and will focus on finding examples of Calculus I and other STEM courses in higher education currently using mastery-grading. I will investigate the detailed objectives, course grading structure, and record-keeping mechanisms of these implementations. These examples will inform the many decisions listed in the tasks for the remaining weeks. As I work through and complete this research, I will design a FLEX presentation on mastery-grading with specific emphasis on STEM courses to offer for faculty beginning in Spring 2024. This FLEX presentation will discuss the drawbacks of tradition points-based systems, the benefits of mastery-based systems, different implementations of mastery-based systems in STEM classrooms, steps to convert a course to mastery-based grading, and resources for further information.

Week 5: Create a set of 20 - 35 clearly-defined, individually assessable learning outcomes for the course based on the student learning outcomes of record. See step 2 of question 4.

Week 6 - 7: Create assessments and reassessments for each outcome. See step 3 of question 4. This work will result in no less than 150 individual assessment questions.

Week 8 - 11: Design a course grading structure based on mastery to determine final grades in the course. See step 4 of question 4. Based on the research done in the first month of the project and the outcomes and assessments subsequently created, I will design the course structure for how grades will be determined that answers the following questions:
How often is each outcome required to be demonstrated?
Is this number consistent for all outcomes or are some outcomes required to be demonstrated more than others?
Are any outcomes bundled together in a quiz that requires a minimum number of outcomes mastered to be passed? See the example of a Foundations Quiz in Step 4 in question 4.
How will weekly homework assignments be awarded credit and how will that credit factor into the final course grade?
How does my department's requirement of a comprehensive final exam during finals week (an exam that cannot be revised or reattempted) factor into the grading structure for the course?
How does a student earn each of the letter grades for the course?

Week 12 - 13: Design a structure of assessments and reassessments that are manageable for the instructor and beneficial for the students. See step 5 of question 4. I will design an assessment structure that includes the following:

How often are in-class assessments conducted and at what points in the curriculum?
How often are students allowed to reassess specific problems/outcomes?
Does a student have to fulfill any specific requirements in order to reassess, for example some type of work or form documenting time spent working towards mastery?
How will students who wish to reassess outside of class be given equal opportunity to do so, regardless of whether they can attend Student Hours?

Weeks 14 – 16: Design and set-up record-keeping structures for assessments, reassessments, and final course grades. Once all of the pieces of the course are determined, I must create efficient structures for managing and tracking course requirements. As mentioned in question 4, gradebooks in Canvas and on other software are not set-up to do this, so I will need to use the research from the first month of this project and my own experience from FA22 to design and create these structures for myself. Specifically, I will design the following:
A system that tracks student achievement of course outcomes.
A mechanism for tracking reassessments of outcomes.
A structure that records student progress toward a final course grade that can be shared with and communicated to students following FERPA laws.
Student-facing documentation describing the structure and policies of the course grading system to be provided to the students at the beginning of the course with they syllabus.

References

Benson, T.H. (2006, April 14). The 7 deadly sins of students. The Chronicle of Higher Education. Available at http://chronicle.com/article/The-7-Deadly-Sins-of-Students/46719/

Butler, R., & Nisan, M. (1986). Effects of no feedback, task-related comments, and grades on intrinsic motivation and performance. Journal of Educational Psychology, 78(3), 210.

Nathan, R. (2005). My freshman year: What a professor learned by becoming a student. Ithaca, NY: Cornell University Press.

Nilsen, L.B. (2015). Specifications Grading: Restoring Rigor, Motivating Students, and Saving Faculty Time. Sterling, VA: Stylus Publishing, LLC.

Singleton-Jackson, J.A., Jackson, D.L., & Reinhardt, J. (2010). Students as consumers of knowledge: Are they buying what we're selling? Innovative Higher Education, 35(4), 343-358.

February 3, 2023

To the Sabbatical Committee:

The Mathematics Department at the Pleasant Hill Campus strongly supports Lindsey Lang in her request for a sabbatical project. The past few years have seen numerous changes to the mathematics program including the loss of basic skills courses due to AB705, the launch of Guided Pathways, and learning loss due to the pandemic. The department has struggled to keep up with the increasing demands from students and their various needs.

Recognizing these challenges, Lindsey recently undertook a course in mastery grading. Lindsey wanted to find ways to support her students and motivate them to succeed. Encouraged by the concept of students taking responsibility for their learning, she ran a pilot of her work in the fall semester of 2022. Lindsey designed multiple forms of assessment for her students in one of her courses, Math 192, with great success. However, mastery grading requires a significant amount of work from the instructor to successfully implement across the entire course. While Lindsey's pilot on her 192 class was successful, her work was not complete. Lindsey is hoping to continue her work in re-designing her Math 192 course to include student-focused mastery grading through her sabbatical project. She intends to share her efforts with other members of the department who may be interested in utilizing a similar technique.

The Math Department is happy to support Lindsey in her pursuit of incorporating mastery grading into her calculus course. The department unanimously approved Lindsey's sabbatical project on February 1, 2023. We look forward to seeing the work that she develops and sharing it with the department.

Sincerely,

Julie Walters
Department Chair
DVC Mathematics

SECTION VI.   SABBATICAL LEAVE REPORT

Lindsey Lang

Name (Open Print Preview to have your name populate throughout the form)

December 2023

Date

Diablo Valley College

College

Fall 2023

Sabbatical leave period requested

Mathematics

Teaching field(s)

GENERAL SUMMARY OF COMPLETED SABBATICAL PROGRAM

(GIVE A 100-WORD MAXIMUM STATEMENT)

During my sabbatical, I converted my Calculus 1 course (Math 192) to an entirely mastery-based course. I researched details of mastery-based implementations in STEM classrooms and used the examples that I found and the studies that I read to create a course of learning activities, assignments, metacognitive activities, and course objective assessments that are based entirely on student demonstration of mastery of objectives. All assessments and assignments are "graded" as successful demonstration of mastery or unsuccessful; there are no points earned in the course. I set up bundles of successful demonstrations required for students to earn final grades in the course, and I created structures to track student progress on all objectives. I compiled all of my materials in a shareable folder that I have shared with my colleagues, and I presented a FLEX workshop in Spring 2024 outlining the basics of mastery-based systems and the details of my Math 192 course.

Lindsey Lang

Name

VALUE TO EDUCATIONAL PROGRAM

Briefly reflect and highlight the value of your sabbatical leave to the educational program. In particular:

1. How will it benefit students, programs, or staff/colleagues?
2. How will it enhance and/or improve your professional competence?
3. How will it relate to your ongoing professional assignment?
4. How are the breadth and depth of the project appropriate for the sabbatical leave rather than the regular teaching year?

Include what you experienced and discovered during the process of completing your sabbatical.

1. How will it benefit students, programs, or staff/collegues?

Converting my Math 192 course to a mastery-based course benefits teachers and students by reducing conflict and stress associated with traditional grading and by focusing the students on learning rather than playing the points game. As a result, the focus of the mastery-based classroom becomes depth of learning, and conversations shift from "how many points do I need for an A?" to "how do I show that I have mastered this concept?". Eliminating aspects of the classroom that do not promote learning benefits everyone.

In addition, with recent legislative mandates like AB705 and AB1705, math facutly are finding that many of the students now in their higher level math classes are coming in with less background and experience in the prerequisite skills needed to be successful in their classes. With more material to cover and review in every class, it is more important than ever to shift the focus to mastery and spend less time worrying about earning points. Since mastery systems give students ongoing chances to demonstrate mastery throughout the semester, students in this system have more flexibility to learn on a realistic timeline and more motivation to continue, as their efforts are not stifled by high stakes exams.

2. How will it enhance and/or improve your professional competence?

By taking the time to build an entirely mastery-based Calculus course, I have taken major steps towards shifting the focus of my student's classroom experience. The course is distilled to the essentials, and everything is built around mastery of those essentials, eliminating the many distractions of the traditional points-based system that demotivates students and teachers with high stakes exams and power struggles over points. I can now build a culture in my classroom where learning is the reward and making mistakes and seeking help are critical parts of the learning process.

3. How will it relate to your ongoing professional assignment?

I teach Math 192 almost every semester, so this project relates directly to my teaching assignment on an ongoing basis. I also have shared my materials and resources with my collegues and continue to to assist those that have adopted them this spring. I plan to use this project's outcomes on my other courses as well, hopefully one day soon teaching all of my classes in this manner. Finally, I'm hoping that over time I can compare my disaggregated retention and success course data from points-based and mastery-based semesters to note any significant changes that may occur, particularly around equity gaps that tend to exist in all math classes.

4. How are the breadth and depth of the project appropraite for the sabbatical leave rather than the regular teaching year?

Educational practices continue to evolve, and I strive to stay updated on educational research related to all aspects of my career. However, it's not easy to implement major changes to curriculum and/or pedagogy while teaching a full load of classes; the process is just too time intensive to properly complete with the myriad of other responsibilities that occur during the semester. By taking the time to fully focus on this project during my sabbatical, I was able to dive into research, learn from the examples that I found, think deeply about my students' needs and thoughtfully create a course that meets those needs. Now I have a fully developed and well-considered starting point from which to continue to refine and revise as I teach the course and experience the new structure. I have also now had the time to thoughtfully consider the many questions that go into structuring a mastery-based course, as well as to research and create the tracking structures that are critical for success in such a course. With that effort under my belt, it will be much easier and less time consuming to take these ideas and structures and apply them to my other courses, so that I can now convert Math 193 to a mastery-based course without needing the time of a sabbatical to do so.

Overall, I am thrilled that I made the decision to apply for and complete this sabbatical. I have been a full-time instructor at DVC for 18 years and this is the first time I ever applied for a sabbatical, because it is the first time that I was passionate enough about a project to want to devote this level of time and energy to it. It has been challenging and rewarding, and I am so excited to see how the implementation of this new course system is received by the students.

Lindsey Lang

Name

PROPOSED OBJECTIVES AND EVIDENCE OF COMPLETION

Identify specific objectives proposed in your application and describe in detail the evidence that accompanies your report, which indicates that you have met each objective. If there are deviations, please explain. Examples follow:

Institutional study
Objective: *9 units graduate level history courses as indicated on Form A-1 will be taken at University.*
Evidence: *(Your statements of evidence should align with and be closely tied to the items listed in the original application. Any deviations from the original proposal must be approved in advance by following the modification procedure delineated in Human Resources Procedure 2040.01. All approved deviations from the original proposal must be outlined and explained in the final sabbatical leave report.)*

Travel
Objective: *Travel to archeological zones in Central America.*
Evidence: *(Here you describe exactly what you are submitting to document your sabbatical leave travel. Your statements of evidence should parallel the items listed in the original application. Any deviations from the original proposal must be approved in advance by following the modification procedure delineated in Human Resources Procedure 2040.01. All approved deviations from the original proposal must be outlined and explained in the final sabbatical leave report.)*

Professional study and/or creative study
Objective: *Compose a musical score or write a textbook.*
Evidence: *(The products of your study should be described and quantified to the extent possible. They should parallel the items listed in the original application. Any deviations from the original proposal must be approved in advance by following the modification procedure delineated in Human Resources Procedure 2040.01. All approved deviations from the original proposal must be outlined and explained in the final sabbatical leave report.)*

Summary of Evidence

Objective as stated in proposal	**Evidence as stated in proposal**	**Evidence provided in this report** *(Give page number, item in portfolio, video, etc.)*
1. Create course objectives for a mastery-based system for Math 192.	A set of 20 - 35 clearly-defined, individually assessable learning outcomes for the course based on the student learning outcomes of record.	Math 192 Learning Objectives on pages 11 and 12.
2. Create assessments and reassessments for the course objectives for Math 192.	A set of assessment questions for each of the created outcomes, with a minimum of 150 individual assessment questions total.	210 assessment questions, separated by sub-skill in each objective on pages 16 through 80.

3. Create a mastery-based course grading structure for Math 192.	A clearly-defined course structure for how final grades are calculated based on the course activities, assignments, and assessments. This structure will address how many outcomes need to be mastered for each final course grade, as well as how homework and the final exam factor into the course grade.	Assessment Grading Details on page 81. Revision Form on page 82. New Attempt Form on page 83. Math 192 Weekly Homework Report on page 86. Final Course Grade Requirements on page 87.
4. Create a record-keeping system for the mastery-based Math 192.	A system that tracks student achievement of course outcomes, a mechanism for tracking reassessment of outcomes, a structure that records student progress toward final grades that can be shared with students, and student-facing documentation describing the structure and policies of course grading in the mastery-based system.	Sample gradebook on page 88. This aspect of the project is difficult to share on paper because it requires processes of creating pivot tables in excel and using the mail merge system to send progress reports to students.
5. Research mastery-based implementations in STEM and present information in a FLEX workshop.	A workshop that presents the drawbacks of tradition points-based systems, the benefits of mastery-based systems, different implementations of mastery-based systems in STEM classrooms, steps to convert a course to mastery-based grading, and resources for further information.	Implementing a Mastery-Based System in Math -192 power point slides on pages 89 through 98 from Spring 2024 FLEX week.
6.		

Lindsey Lang

Name

INSTITUTIONAL STUDY **Form A-1**	
Name of Institution	*Place of Institution*
Period of Attendance	*Units completed semester/quarter*
One copy of your official transcript must be filed with this report	

Lindsey Lang

Name

TRAVEL
Form B-1

Give Itinerary:

Place	Dates of Visit	Purposes Achieved

Lindsey Lang

Name

PROFESSIONAL STUDY AND/OR CREATIVE STUDY

Form C-1

Summarize the study methods, resources, activities and results. Quantify your summary wherever possible, listing pages written, scores composed, etc., as appropriate.

I began my project by doing some research on mastery-grading implementations in mathematics and STEM classrooms. I read UNgrading, Why Rating Students Undermines Learning (and What to Do Instead), a collection of articles written by educators outlining their process and experience in mastery-based grading systems. I also reread Spcifications Grading, which contains a number of very detailed examples of mastery-grading implementations. I continued to follow the Grading for Growth weekly blog, going back to previous entries specifically geared towards STEM classroom implementations. These resources directed me to The Grading Conference website, which contains a bank of resources from past conferences. This website gave me access to an entire repository of Mathematics (and other STEM discipline) resources from mastery-based courses, including syllabi, objectives lists, course grading schemes, feedback marks and tracking systems. I read through all of these materials carefully, taking notes and compiling ideas for how to create and structure my own course.

Next, I created a first draft of clearly-defined learning objectives for Math 192 based on the student learning outcomes of record. While the SLOs on the course outline are an important starting point, the objectives that I will be utilizing in my course need to be student-facing and parced into more individually assessable statements. These objectives were edited and refined throughout the remaining steps of my process outlined below. See Math 192 Learning Objectives on pages 11-12 of this report.

Once I had objectives created, I revisited the course material for the class, ensuring that every learning activitiy and resource was connected and mapped to at least one of my course objectives. From that point, I began creating assessments for each individual objective. Since students will be allowed to reattempt mastery demonstration for each objective, every objective needs to have multiple versions of assessment questions to allow for a variety of opportunity to demonstrate mastery throughout the semester. Furthermore, many objectives have more than one implementation in the course, so I created a list of sub-skills for those objectives and then created multiple assessments of each subskill. See Math 192 Learning Objectives Assessment Breakdown on pages 13-15 of this report and the assessment questions for each objective on pages 16-80 of this report.

Communicating the system to the systems is critically important to success. At this stage of the project, I created a series of documents that would be shared with the students to clearly describe how the assessment process works - how assessments are "graded" and how they revise and reattempt unsuccessful assessment attempts. See Assessment Grading Details, Revision Form, and New Attempt Form on pages 81-83 of this report.

I then mapped out when during the course I would give students assessments in class, and exactly which objectives and which sub-skills would be assessed on each date. This mapping allowed me to set up the final list of how a student "masters" an objective. If there are four subskills assessed throughout the semester for that objective, then the student must be successful on four separate assessments of that objective in order to master it. Once the number of successful assessments per objective was determined, I created a student tracking log for students to use to keep track of how many times they have successful demonstrations of each objective. See the Student Mastery Checklist on pages 84-85 of this report.

My next task involved determining how a final grade in the course would be assigned. Since I had already determined how each of the 27 course objectives would be mastered, I began with deciding how many of these would need to be mastered for a student to earn an A, how many for a B, etc. I based this decision on a couple of factors, first calculating 90% of 27, 80% of 27, etc, and also having conversations with colleagues about what students need to know in order to be successful in the next class, Math 193. After deciding how lesson mastery factored into the final grade, I needed to finalize the role that homework and classwork would play in course grades. Each lesson in the course has both an in-class worksheet and an online homework assignment, but in a mastery-based system, these items are not collected and graded in the traditional sense. Instead, to focus the students on thinking about their learning and engaging in self-assessment about course content, I created a weekly homework report that each student completes and submits at the end of each week. The report asks the students to outline what learning tasks they have engaged in outside of class, and whether or not they feel confident in the material based on doing the reported amount of work. They can also ask any outstanding question on the report. See Math 192 Weekly Homework Report on page 86 of this report. Successfully completing homework reports is another aspect of earning a final grade in the course, with the number of reports part of each bundle needed to earn an A, B, etc.

One last qustion remained about final course grades: how does the department required comprehensive final exam factor into the mastery-based system, since no reattempts will be possible? Once I setup my course calendar, I determined that there would be two yet unassessed objectives on the final exam. I will give the students choices of problems to master on the final for these last two objectives, so they have multiple opportunities on the day to demonstrate their knowledge. In addition, the rest of the final exam will contain a group of assessments on the fundamental objectives in the rest of the course. These will count towards mastery of these objectives, but will also be graded in such a way that the emphasis will be on the Calculus objective, and minor errors in arithmetic and algebra will not affect success since students will not have an opportunity to reattempt these assessments. Thus, the final exam is actually the last time students can demonstrate mastery and is folded into the objective mastery aspect of final course grades. I now have a simple way to determine final course grades for students. See Final Course Grade Requirements on page 87 of this report.

Lastly, keeping track of revisions, new attempts, and objective mastery can be quite a challenge. Traditional gradebooks, including the Canvas gradebook, are not designed to effectively track these type of actitives and results for a course. This course requires a system that tracks student achievement of subskill assessments and mastery of course outcomes, that logs all attempts students have made on assessments to avoid duplication, and that records student progress towards final grades and can be shared with students so they can check their progress. I was thrilled to discover an instructor with a series of You Tube videos outlining in detail how he used pivot tables in Excel to track all these items, then used a mail merge to email progress reports to the students. After many hours of work, I was able to adapt his process to make it fit what I wanted for my course, giving me an effective and efficient way to keep track of all the details and easily communicate grade details with students. This tracking program is harder to share on paper, but I did include a sample gradebook output on page 88 of this report.

I compiled all of this process and information into a FLEX presentation that I gave in January 2024. See Implementing Mastery-Based Grading in Math-192 on pages 89-98 of this report for the Power Point slides. I shared all the documents from this project, including student handouts and all objective assessments, as well as other resources like classroom worksheets with all math faculty via a shared OneDrive folder. I currently have two other math colleagues implementing some version of these materials and grading structures in their current Math 192 courses, and we continue to discuss ideas and troubleshoot as issues arise this semester.

References

Blum, Susan D. (2020). UNgrading: Why Rating Students Undermines Learning (and What to Do Instead). Morgantown: West Viginia University Press.

Nilsen, L.B. (2015). Specifications Grading: Restoring Rigor, Motivating Students, and Saving Faculty Time. Sterling, VA: Stylus Publishing, LLC.

Talbert, Robert. Grading for Growth blog. http://gradingforgrowth.com

The Grading Conferences Math Respository of Mastery Grading syllabi and other resources for University level Mathematics: Masterygrading.com/resources.

Math 192 Learning Objectives

Precalculus

P1. I can compute average rates of change and find slopes of secant lines. (2)

P2. I can graph functions and identify main characteristics (domain, intercepts, asymptotes) with minimal technological assistance, given a formula. (2)

P3. I can rewrite an absolute value as a piecewise function. (1)

P4. I can evaluate trigonometric functions at known values.

Limits

L1. I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation. (2)

L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation. (5)

L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them. (5)

L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits. (2)

L5. I can evaluate the limit of an expression "at" infinity and use these limits to determine asymptotes. (2)

Differentiation Rules

D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable. (2)

D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context. (2)

D3. I can find the equation of the tangent line to a function at a point. (3)

D4. I can compute derivatives of polynomial, exponential, and logarithmic functions. (3)

D5. I can compute derivatives using the product and quotient rules. (4)

D6. I can compute derivatives of trigonometric and inverse trigonometric functions. (4)

D7. I can compute derivatives of composite functions using the Chain Rule. (5)

D8. I can compute the derivative of an implicitly defined function using implicit differentiation. (2)

Applications of Differentiation

A1. I can sketch f, f', or f'' given a graph of f, f', or f''. (2)

A2. I can use derivatives to solve problems in the natural and social sciences. (1)

A3. I can use derivatives to solve problems involving related rates of change. (2)

A4. I can find all critical points, local extrema, and inflection points of a given function. (4)

A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function. (2)

A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems. (3)

Integration

I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives. (2)

I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals. (1)

I3. I can evaluate definite integrals using only simple geometric formulas. (1)

I4. I can evaluate definite integrals using the Fundamental Theorem of Calculus. (1)

Math 192 Learning Objectives

I5. I can use definite integrals to measure change. (2)

I6. I can evaluate integrals using the substitution method. (3)

Math 192 Learning Objectives Assessment Breakdown

Precalculus

P1. I can compute average rates of change and find slopes of secant lines. (2)

P1.1 Find slope of secant line.

P1.2 Find average velocity.

P2. I can graph functions and identify main characteristics (domain, intercepts, asymptotes) with minimal technological assistance, given a formula. (2)

P2.1 Find the domain and vertical asymptotes of a rational function.

P2.2 Graph a piecewise function.

P3. I can rewrite an absolute value as a piecewise function. (1)

P4. I can evaluate trigonometric functions at known values.

Limits

L1. I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation. (2)

L1.1 Identify limits from a graph, including those that don't exist.

L1.2 Construct a graph of a function that meets given limit statements.

L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation. (5)

L2.1 Identify limits analytically using direct substitution.

L2.2 Identify limits analytically at the breakpoint of a piecewise function using one-sided limits.

L2.3 Identify limits analytically for a function that requires simplification first.

L2.4 Identify limits analytically for a function that contains an absolute value.

L2.5 Identify limits analytically at a point where there is a one-sided infinite limit.

L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them. (5)

L3.1 Factor and cancel when 0/0.

L3.2 Rational function containing a radical when 0/0.

L3.3 Exponential L'Hopital (1 to infinity, 0 to 0, 0o to infinity)

L3.4 L'Hopital product (0 times infinity).

L3.5 L'Hopital difference (infinity – infinity).

L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits. (2)

L4.1 Identify discontinuities graphically and classify their type.

L4.2 Identify discontinuities from equation and identify why each point is discontinuous.

L5. I can evaluate the limit of an expression "at" infinity and use these limits to determine asymptotes. (2)

Differentiation Rules

D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable. (2)

D1.1 Compute derivative at a point using definition.

D1.2 Setup the limit definition of the derivative of a function.

D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context. (2)

D2.1 Interpret meaning of the derivative given a real-world function, including units.

D2.2 Interpret the derivative as the slope of the curve given a graph.

D3. I can find the equation of the tangent line to a function at a point. (3)

D3.1 Find the equation of the tangent line to a function at a point.

D3.2 Find the points where the tangent line is horizontal (includes D6).

D4. I can compute derivatives of polynomial, exponential, and logarithmic functions. (3)

D4.1 Derivatives using power and coefficient rules.

D4.2 Derivatives of exponentials (includes D5).

D4.3 Derivatives of logarithms (includes D5).

D5. I can compute derivatives using the product and quotient rules. (4)

D5.1 Derivatives using product rule.

D5.2 Derivatives using quotient rule.

D6. I can compute derivatives of trigonometric and inverse trigonometric functions. (4)

D6.1 Derivatives of trig functions.

D6.2 Derivatives of inverse trig functions.

D7. I can compute derivatives of composite functions using the Chain Rule. (5)

D7.1 Chain rule involving inverse trig (also D6.2)

D7.2 Chain rule involving logs.

D7.3 Chain rule involving radicals

D7.4 Chain rule involving

D8. I can compute the derivative of an implicitly defined function using implicit differentiation. (2)

Applications of Differentiation

A1. I can sketch $f, f', $ or f'' given a graph of $f, f', $ or f''. (2)

A1.1 Sketch the graph of the derivative of a given graph.

A1.2 Identify graph of function and its derivatives, given all graphs.

A2. I can use derivatives to solve problems in the natural and social sciences. (1)

A2.1 Motion analysis

A3. I can use derivatives to solve problems involving related rates of change. (2)

A4. I can find all critical points, local extrema, and inflection points of a given function. (4)

A4.1 Find critical numbers from equation and classify them as max, min, or neither.

A4.2 Find inflection points from equation.

A4.3 Find extrema and inflection points from graph of first derivative.

A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function. (2)

A5.1 Describe relationship between first derivative, second derivative, and graph of function.

A5.2 Sketch graph given info on derivative and limits

A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems. (3)

A6.1 Absolute extrema of continuous function on a closed interval.

A6.2 Solve optimization problems.

Integration

I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives. (2)

I1.1 General antiderivatives.

I1.2 Particular antiderivative with initial condition.

Math 192 Learning Objectives Assessment Breakdown

I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals. (1)

I2.1 Find area under the curve using limits of Riemann sums.

I2.2 Setup limit of Riemann sums that defines area; do not evaluate.

I2.3 Use limit of Riemann sums to identify region whose area is specified.

I3. I can evaluate definite integrals using only simple geometric formulas. (1)

I4. I can evaluate definite integrals using the Fundamental Theorem of Calculus. (1)

I5. I can use definite integrals to measure change. (2)

I6. I can evaluate integrals using the substitution method. (3)

Assessment questions for P1: I can compute average rates of change and find slopes of secant lines.

P1.1: Slopes of secant lines.

P1.1, v1: Let P be the point (1, -1) on the graph of the function $f(x) = x^2 - 2$. Find the slope of the secant line through P and Q if the x-coordinate of Q is $\frac{5}{4}$. If necessary, round to three decimal places, but not until the end of your calculations.

P1.1, v2: Let P be the point (1, 2) on the graph of the function $f(x) = x^2 + 1$. Find the slope of the secant line through P and Q if the x-coordinate of Q is 1.1. If necessary, round to three decimal places, but not until the end of your calculations.

P1.1, v3: Let P be the point (2, -1) on the graph of the function $f(x) = \frac{1}{1-x}$. Find the slope of the secant line through P and Q if the x-coordinate of Q is 2.01. If necessary, round to three decimal places, but not until the end of your calculations.

P1.2: Average velocity

P1.2, v1: If a rock is thrown upwards on the planet Mars with a velocity of 10m/s, its height in meters t seconds later is given by $h = 10t - 1.86t^2$. Find the average velocity of the rock over the time interval [1, 1.1]. Round your answer to three decimal places at the end of your calculation and include proper units.

P1.2, v2: If a rock is thrown upwards on with a velocity of 40 ft/s, its height in feet t seconds later is given by $h = 40t - 16t^2$. Find the average velocity of the rock over the time interval beginning at $t = 2$ and lasting 0.05 seconds. Round your answer to three decimal places at the end of your calculation and include proper units.

P1.2, v3: The position (in meters) of an object moving in a straight line is given by $s = 1 + 2t + \frac{1}{4}t^2$, where t is measured in seconds. Find the average velocity over the interval [1.5, 1.55]. Round your answer to three decimal places at the end of your calculation and include proper units.

Assessment questions for P2: I can graph functions and identify main characteristics (domain, intercepts, asymptotes) with minimal technological assistance, given a formula.

P2.1: Domain and asymptotes.

P2.1, v1: Find the domain of $h(x) = \frac{x^2-x-2}{2x^2-x-6}$ and identify any vertical asymptotes.

P2.1, v2: Find the domain of $h(x) = \frac{2x^2-5x-3}{3x^2-7x-6}$ and identify any vertical asymptotes.

P2.1, v3: Find the domain of $h(x) = \frac{2x^2+9x+10}{4x^2+4x-15}$ and identify any vertical asymptotes.

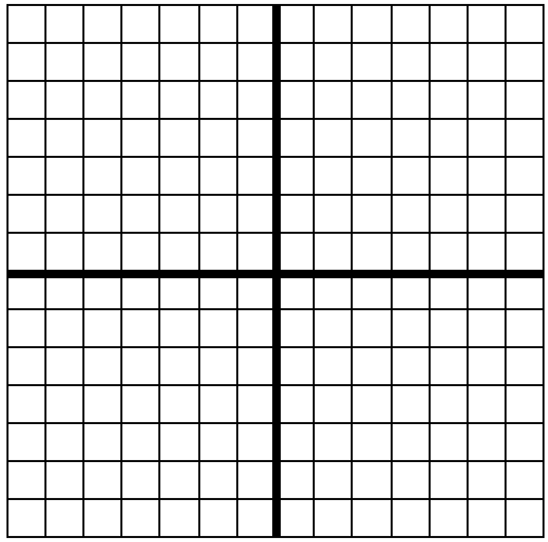
P2.1, v4: Find the domain of $h(x) = \log_2(2x+8)$ and identify any vertical asymptotes.

P2.1, v5: Find the domain of $h(x) = \log_2(6-x)$ and identify any vertical asymptotes.

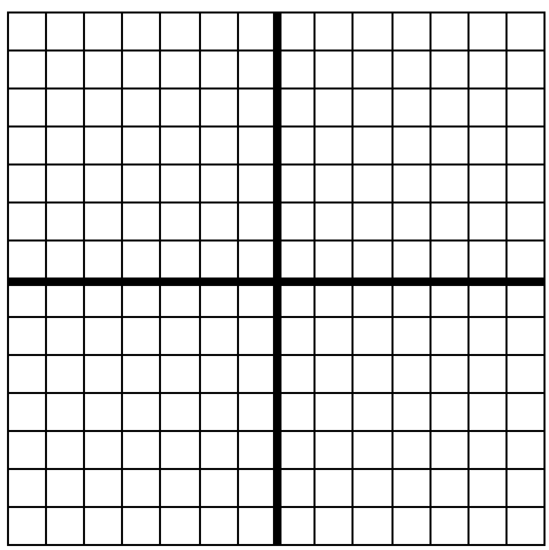
P2.1, v6: Find the domain of $h(x) = \log_2\left(\frac{x}{2}-1\right)$ and identify any vertical asymptotes.

P2.2: Graph a piecewise

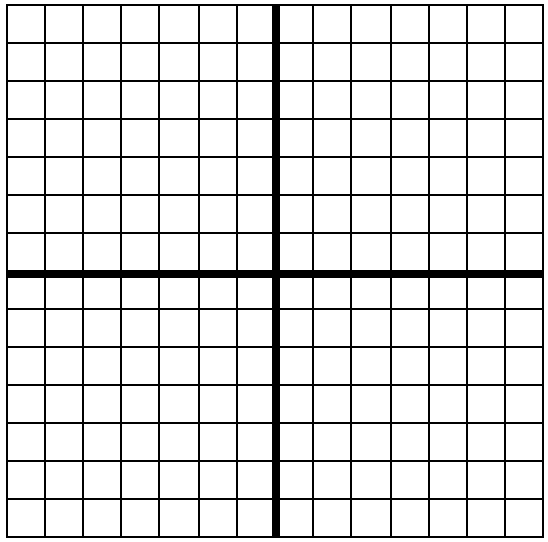
P2.2, v1: Construct an accurate graph of $f(x) = \begin{cases} x^2+1, & if\ x < 1 \\ (x-2)^2, & if\ x \geq 1 \end{cases}$ on the axes provided.



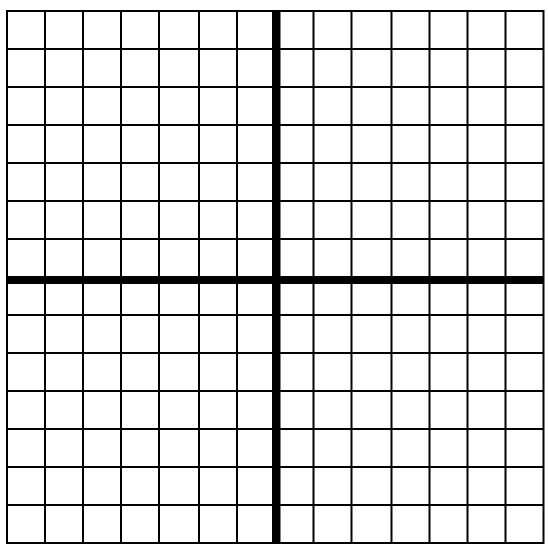
P2.2, v2: Construct an accurate graph of $f(x) = \begin{cases} \sqrt{-x}, & if\ x < 0 \\ 3 - x, & if\ 0 \leq x < 3 \\ (x-3)^2, & if\ x > 3 \end{cases}$ on the axes provided.



P2.2, v3: Construct an accurate graph of $f(x) = \begin{cases} 3x, & if\ \ x < 0 \\ 4, & if\ 0 \leq x \leq 4 \\ \sqrt{x}, & if\ \ x > 4 \end{cases}$ on the axes provided.



P2.2, v4: Construct an accurate graph of $f(x) = \begin{cases} x^2 - 3, & if\ x < 1 \\ (x-3)^2, & if\ x \geq 1 \end{cases}$ on the axes provided.



Assessment questions for P3: I can rewrite an absolute value function as a piecewise function.

P3, v1: Rewrite the function $g(x) = |6 - 4x|$ as a piecewise function.

P3, v2: Rewrite the function $g(x) = |2 - 5x| + 3$ as a piecewise function.

P3, v3: Rewrite the function $g(x) = -2|8 - x|$ as a piecewise function.

P3, v4: Rewrite the function $g(x) = 9 - |2x + 5|$ as a piecewise function.

P3, v5: Rewrite the function $g(x) = |1 - 7x| - 3$ as a piecewise function.

P3, v6: Rewrite the function $g(x) = -3|1 - 10x|$ as a piecewise function.

P3, v7: Rewrite the function $g(x) = |12 - 7x|$ as a piecewise function.

Assessment questions for P4. I can evaluate trigonometric functions at known values.

P4, v1: Without a calculator, evaluate $\sin\frac{2\pi}{3}$.

(I can evaluate trigonometric functions at known values.)

P4, v2: Without a calculator, evaluate $\cos\frac{5\pi}{4}$.

(I can evaluate trigonometric functions at known values.)

P4, v3: Without a calculator, evaluate $\tan\frac{7\pi}{4}$.

(I can evaluate trigonometric functions at known values.)

P4, v4: Without a calculator, evaluate $\csc\frac{11\pi}{6}$.

(I can evaluate trigonometric functions at known values.)

P4, v5: Without a calculator, evaluate $\tan\pi$.

(I can evaluate trigonometric functions at known values.)

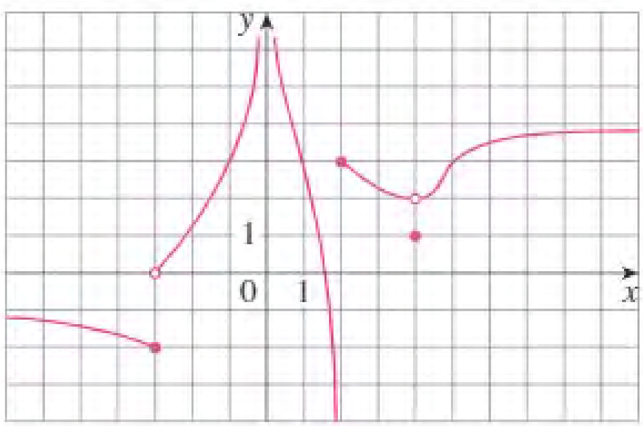
P4, v6: Without a calculator, evaluate $\sin(-\frac{\pi}{2})$.

(I can evaluate trigonometric functions at known values.)

Assessment questions for L1. I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.

L1.1: Identifying limits from a graph, including those that don't exist.

L1.1, v1: The graph of f is given. Find each limit, or explain why it does not exist.



a) $\lim_{x \to 2^+} f(x)$

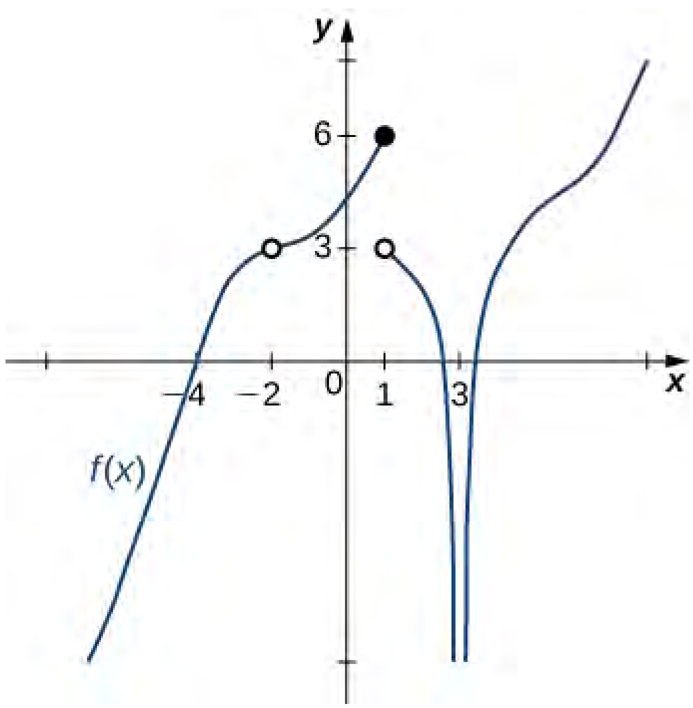
b) $\lim_{x \to -3^+} f(x)$

c) $\lim_{x \to 4} f(x)$

d) $\lim_{x \to 2^-} f(x)$

(I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L1.1, v2: The graph of f is given. Find each limit, or explain why it does not exist.



c) $\lim_{x \to 1^+} f(x)$

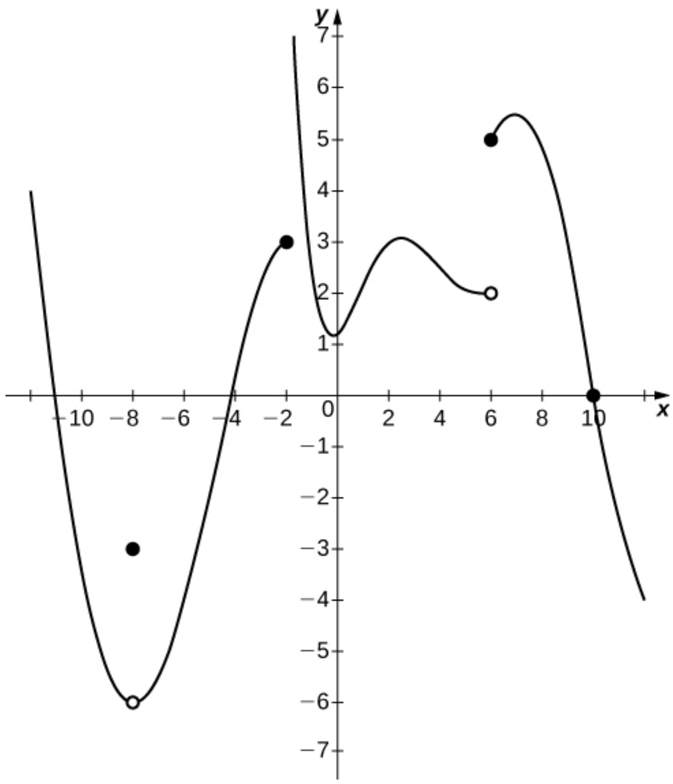
d) $\lim_{x \to 1^-} f(x)$

e) $\lim_{x \to 3} f(x)$

f) $\lim_{x \to -2} f(x)$

(I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L1.1, v3: The graph of f is given. Find each limit, or explain why it does not exist.



e) $\lim_{x\to-8} f(x)$

f) $\lim_{x\to-2^+} f(x)$

g) $\lim_{x\to6} f(x)$

h) $\lim_{x\to10} f(x)$

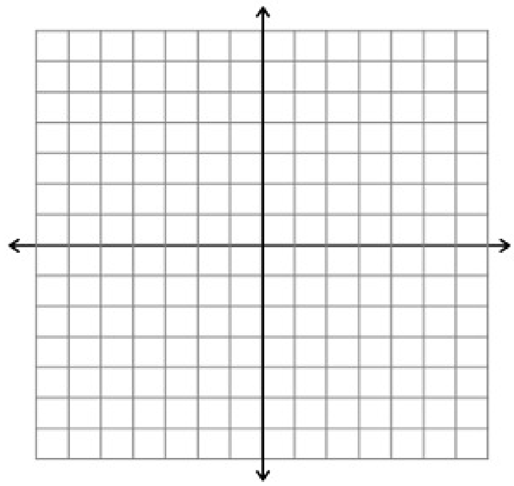
(I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L1.2: Constructing a graph given limit statements.

L1.2, v1: Sketch the graph of an example of a function f that satisfies all of the following conditions:

$\lim_{x \to 0} f(x) = 1$ $\lim_{x \to 3^-} f(x) = -2$ $\lim_{x \to 3^+} f(x) = 2$ $f(0) = -1$ $f(3) = 1$

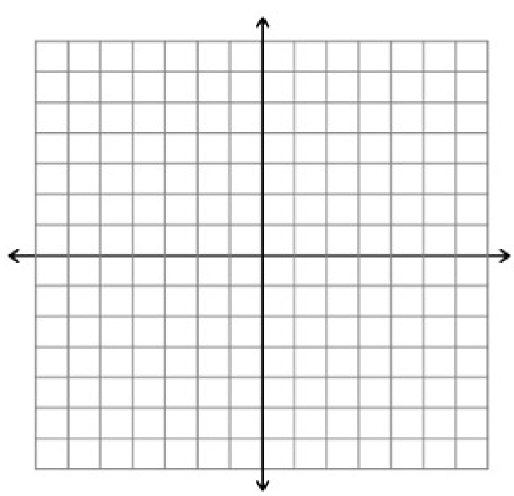
(I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)



L1.2, v2: Sketch the graph of an example of a function f that satisfies all of the following conditions:

$\lim_{x \to -2} f(x) = 2$ $\lim_{x \to 3^-} f(x) = 2$ $\lim_{x \to 3^+} f(x) = 4$ $f(-2) = -1$ $f(3) = 3$

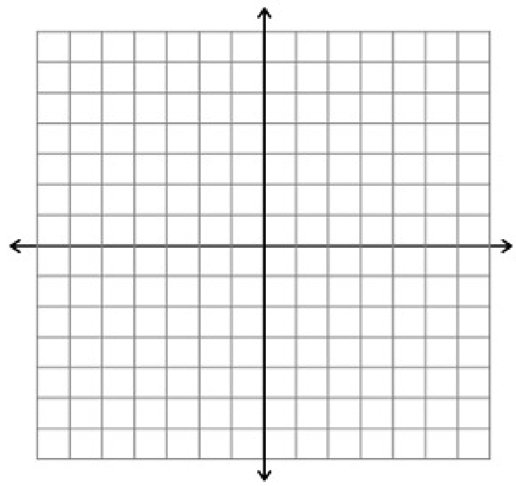
(I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)



L1.2, v3: Sketch the graph of an example of a function f that satisfies all of the following conditions:

$\lim_{x\to 0^-} f(x) = 2$ $\lim_{x\to 0^+} f(x) = 0$ $\lim_{x\to 4^-} f(x) = 3$ $\lim_{x\to 4^+} f(x) = 0$

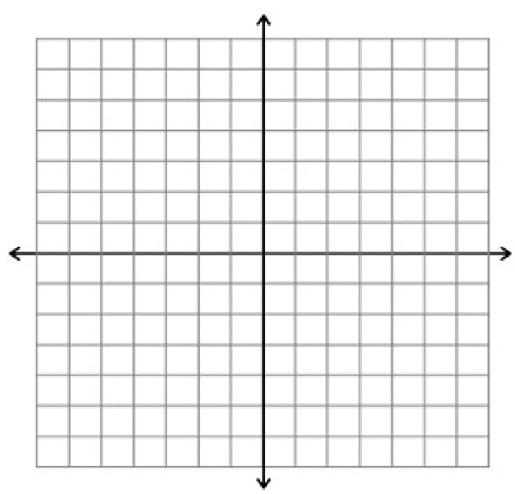
$f(0) = 2$ $f(4) = 1$



(I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L1.2, v4: Sketch the graph of an example of a function that satisfies all of the following conditions:

$\lim_{x\to 3^+} f(x) = 4,$ $\lim_{x\to 3^-} f(x) = 2,$ $f(3) = 3,$ $\lim_{x\to 0^+} f(x) = \infty,$ $f(0) = -1$



(I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

Assessment questions for L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.

L2.1: Identifying limits analytically, direct substitution.

L2.1, v1: Evaluate or explain why the limit doesn't exist: $\lim_{x\to 1} \ln\left(\frac{5-x^2}{1+x}\right)$

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.1, v2: Evaluate or explain why the limit doesn't exist: $\lim_{x\to 2} \; x\sqrt{20-x^2}$

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.1, v3: Evaluate or explain why the limit doesn't exist: $\lim_{x\to \pi} \sin(x+\sin x)$

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.2: Identifying limits analytically, two-sided breakpoints of piecewise.

L2.2, v1: Let $f(x) = \begin{cases} x^2+1, & if\ x<1 \\ (x-2)^2, & if\ x\geq 1 \end{cases}$. Evaluate $\lim_{x\to 1} f(x)$ or explain why it doesn't exist.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.2, v2: Let $f(x) = \begin{cases} 4(x-1), & if\ x<-1 \\ (x-1)^3, & if\ x\geq -1 \end{cases}$. Evaluate $\lim_{x\to -1} f(x)$ or explain why it doesn't exist.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.2, v3: Let $f(x) = \begin{cases} 3x-4, & if\ x<-1 \\ (x-2)^3, & if\ x\geq -1 \end{cases}$. Evaluate $\lim_{x\to -1} f(x)$ or explain why it doesn't exist.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.3: Identifying limits analytically, function needing simplification.

L2.3, v1: Evaluate or explain why the limit doesn't exist: $\lim_{h \to 0} \left(\frac{1}{h} - \frac{1}{h(h+1)} \right)$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.3, v2: Evaluate or explain why the limit doesn't exist: $\lim_{x \to 3} \left(\frac{\frac{1}{x} - \frac{1}{3}}{x-3} \right)$

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.3, v3: Evaluate or explain why the limit doesn't exist: $\lim_{x \to 1} \left(\frac{1}{x-1} + \frac{1}{x^2-3x+2} \right)$

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.4: Identifying limits analytically, limit of absolute value at breakpoint.

L2.4, v1: Evaluate or explain why the limit doesn't exist: $\lim_{x \to 0} \frac{x}{|x|}$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.4, v2: Evaluate or explain why the limit doesn't exist: $\lim_{x \to -2} \frac{2-|x|}{2+x}$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.4, v3: Evaluate or explain why the limit doesn't exist: $\lim_{x \to 2} \frac{x^2+x-6}{|x-2|}$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.4, v4: Evaluate or explain why the limit doesn't exist: $\lim_{x \to 1} \frac{|x|-1}{x^2-1}$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.4, v5: Evaluate or explain why the limit doesn't exist: $\lim_{x \to -3} \frac{|x|-3}{x^2-9}$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.5: Identifying limits analytically, one sided infinite limit.

L2.5, v1: Evaluate or explain why the limit does not exist: $\lim_{x \to \frac{1}{2}^+} \left(\frac{2x^2-5x-3}{4x^2-1}\right)$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.5, v2: Evaluate or explain why the limit doesn't exist: $\lim_{x \to 2^-} \frac{x^2-2x}{x^2-4x+4}$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

L2.5, v3: Evaluate or explain why the limit doesn't exist: $\lim_{x \to -\frac{1}{3}^+} \frac{x}{\sqrt{1+3x}}$.

(L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation.)

Assessment questions for L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.

L3.1: Identifying limits analytically, factor and cancel when 0/0.

L3.1, v1: Evaluate or explain why the limit does not exist: $\lim_{x\to -3}\left(\frac{x^2+3x}{x^2-x-12}\right)$.

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.1, v2: Evaluate or explain why the limit doesn't exist: $\lim_{x\to -1}\frac{2x^2+3x+1}{x^2-2x-3}$.

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.1, v3: Evaluate or explain why the limit doesn't exist: $\lim_{x\to\frac{1}{2}}\frac{4x^2-1}{2x^2+13x-7}$.

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.2: Identifying limits analytically, rational radical in indeterminate form (0/0).

L3.2, v1: Evaluate or explain why the limit doesn't exist: $\lim_{x\to-1}\frac{\sqrt{x+2}-1}{x+1}$.

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.2, v2: Evaluate or explain why the limit doesn't exist: $\lim_{t\to0}\frac{\sqrt{t^2+9}-3}{t^2}$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.2, v3: Evaluate or explain why the limit doesn't exist: $\lim_{t\to16}\frac{4-\sqrt{t}}{16t-t^2}$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.3: Identifying limits analytically, exponential L'Hopital's (1 to infinity, 0 to 0, 0 to infinity)

L3.3, v1: Evaluate: $\lim_{x\to\infty}\left(1-\frac{3}{x}\right)^x$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.3, v2: Evaluate: $\lim_{x \to 0^+} (\tan 2x)^x$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.3, v3: Evaluate: $\lim_{x \to 0^+} (1 + \sin 3x)^{1/x}$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.4: Identifying limits analytically, product L'Hospital's (0 times infinity)

L3.4, v1: Evaluate: $\lim_{x \to \infty} xsin(\pi/x)$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.4, v2: Evaluate: $\lim_{x \to -\infty} x \ln\left(1 - \frac{1}{x}\right)$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.4, v3: Evaluate: $\lim_{x \to \pi/2^-} \cos x \sec 5x$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

L3.5: Identifying limits analytically, difference L'Hospital's (infinity - infinity)

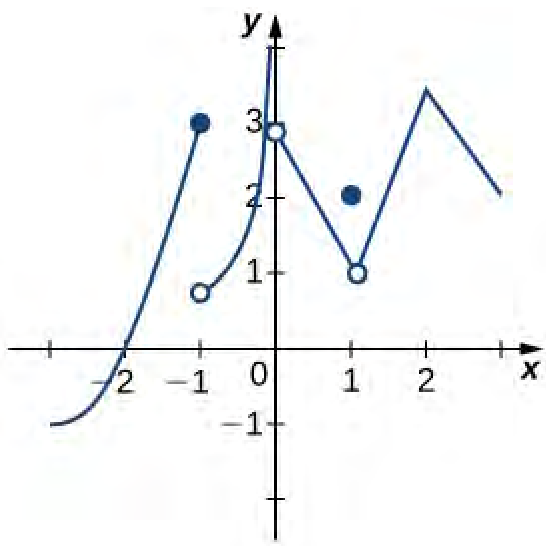
L3.5, v1: Compute $\lim_{x \to 1^+} \left(\frac{1}{\ln x} - \frac{1}{x-1}\right)$

(L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them.)

Assessment questions for L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits.

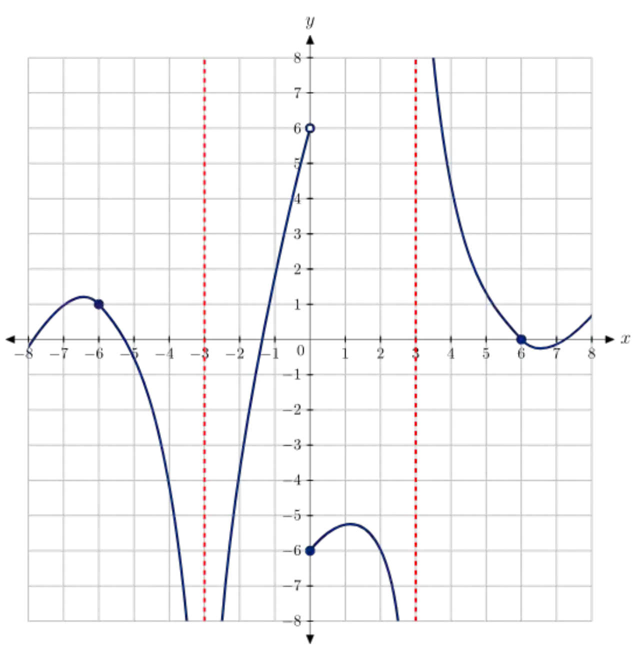
L4.1: Identify discontinuities graphically and classify their type.

L4.1, v1: Consider the graph of the function $y = f(x)$ shown in the following graph. Find all values for which the function is discontinuous. For each value, classify the discontinuity as either jump, removable, or infinite.



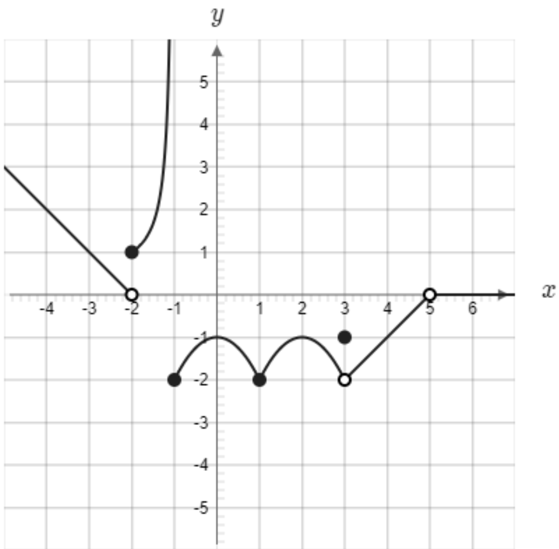
(L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits.)

L4.1, v2: Consider the graph of the function $y = f(x)$ shown in the following graph. Find all values for which the function is discontinuous. For each value, classify the discontinuity as either jump, removable, or infinite.



(L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits.)

L4.1, v3: Consider the graph of the function $y = f(x)$ shown in the following graph. Find all values for which the function is discontinuous. For each value, classify the discontinuity as either jump, removable, or infinite.



(L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits.)

L4.2: Identify discontinuities from equation, with formal statements.

L4.2, v1: Let $f(x) = \begin{cases} \sqrt{-x}, & if\ x < 0 \\ 3 - x, & if\ 0 \leq x < 3 \\ (x-3)^2, & if\ x > 3 \end{cases}$

Find all value(s) for which $f(x)$ is discontinuous and state why the definition of continuity does not apply.

(L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits.)

L4.2, v2: Find all value(s) for which $f(x)$ is discontinuous and state why the definition of continuity does not apply.

$$f(x) = \begin{cases} x^2, & if\ x < -1 \\ x, & if -1 \leq x < 1 \\ 1/x, & if\ x > 1 \end{cases}$$

(L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits.)

L4.2, v3: Find all value(s) for which $f(x)$ is discontinuous and state why the definition of continuity does not apply.

$$f(x) = \begin{cases} 2^x, & if\ x < 1 \\ 3 - x, & if 1 < x \leq 4 \\ \sqrt{x}, & if\ x > 4 \end{cases}$$

(L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits.)

Assessment questions for L5. I can evaluate the limit of an expression "at" infinity and use these limits to determine asymptotes.

L5, v1: Use limits (not graphs or tables) to analyze the end behavior of $f(x) = \sqrt{9x^2 + x} - 3x$. State clearly what this end behavior is.

(L5. I can evaluate the limit of an expression "at" infinity and use these limits to determine asymptotes.)

L5, v2: Use limits (not graphs or tables) to analyze the end behavior of $f(x) = \sqrt{x^2 + x} - x$. State clearly what this end behavior is.

(L5. I can evaluate the limit of an expression "at" infinity and use these limits to determine asymptotes.)

L5, v3: Use limits (not graphs or tables) to analyze the end behavior of $f(x) = \frac{\sqrt{2x^2+1}}{3x-5}$. State clearly what this end behavior is.

(L5. I can evaluate the limit of an expression "at" infinity and use these limits to determine asymptotes.)

Assessment questions for D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable.

D1.1: Compute derivative at a point using definition.

D1.1, v1: Using the definition of the derivative, find the derivative of curve $f(x) = \frac{x}{x+2}$ at the point where $x = -1$.

(D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable.)

D1.1, v2: Using the definition of the derivative, find the derivative of curve $f(x) = \frac{1}{\sqrt{x}}$ at the point where $x = 4$.

(D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable.)

D1.1, v3: Using the definition of the derivative, find the derivative of curve $f(x) = \frac{2x+1}{x-2}$ at the point where $x = -3$.

(D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable.)

D1.2: Setup limit definition of derivative of a function.

D1.2, v1: Create a limit that represents the derivative of the following function, but do not evaluate the limit.

$$f(x) = \frac{x^2 - 1}{2x + 3}$$

(D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable.)

D1.2, v2: Create a limit that represents the derivative of the following function, but do not evaluate the limit.

$$f(x) = x + \frac{1}{x}$$

(D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable.)

D1.2, v3: Create a limit that represents the derivative of the following function, but do not evaluate the limit.

$$f(x) = \frac{2\sqrt{x}}{3x - 1}$$

(D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable.)

Assessment questions for D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.

D2.1 Interpret meaning of a derivative given a real-world function, including units.

D2.1, v1: A concert promoter estimates that the cost of printing p full color posters for a major concert is given by a cost function, $C(p)$, where p is the number of posters produced.

a) Interpret the meaning of the statement $C(550) = 6600$. Include units.
b) Interpret the meaning of the statement $C'(550) = 11$. Include units.

(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

D2.1, v2: A coffee shop determines their daily profit on scones is given by $P(s)$, where s is price of each scone.

a) Interpret the meaning of the statement $P'(4.25) = -0.5$. Include units.
b) Should the company consider raising or lowering the price of scones? Why or why not?

(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

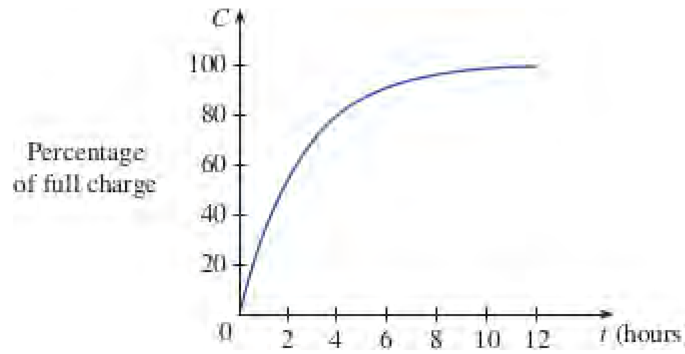
D2.1, v3: The quantity (in pounds) of a gourmet ground coffee that is sold by a coffee company at a price of p dollars per pound is $Q = f(p)$. What is the meaning of $f'(15)$? What are its units? Would you expect that $f'(15)$ is positive or negative and why?

(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

D2.1, v4: Let $H(t)$ be the daily cost (in dollars) to heat an office building when the outside temperature is t degrees Fahrenheit. What is the meaning of $H'(58)$? What are its units? Would you expect that $H'(58)$ is positive or negative and why?

(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

D2.1, v5: A rechargeable battery is plugged into a charger. The graph shows $C(t)$, the percentage of full capacity that the battery reaches as a function of time t elapsed (in hours).

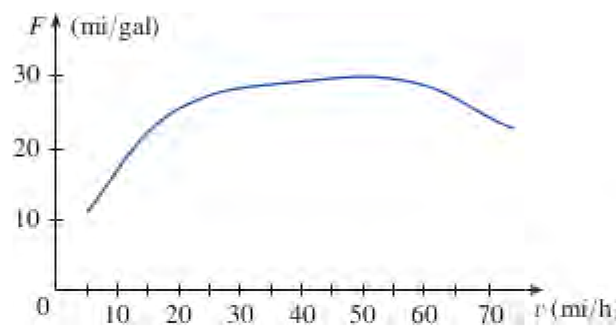


a. What is the meaning of the derivative $C'(t)$?

b. Sketch the graph of $C'(t)$. What does the graph tell you?

(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

D2.1, v6: The graph (from the US Department of Energy) shows how driving speed affects gas mileage. Fuel economy F is measured in miles per gallon and speed v is measured in miles per hour.



a. What is the meaning of the derivative $F'(v)$?

b. Sketch the graph of $F'(v)$.

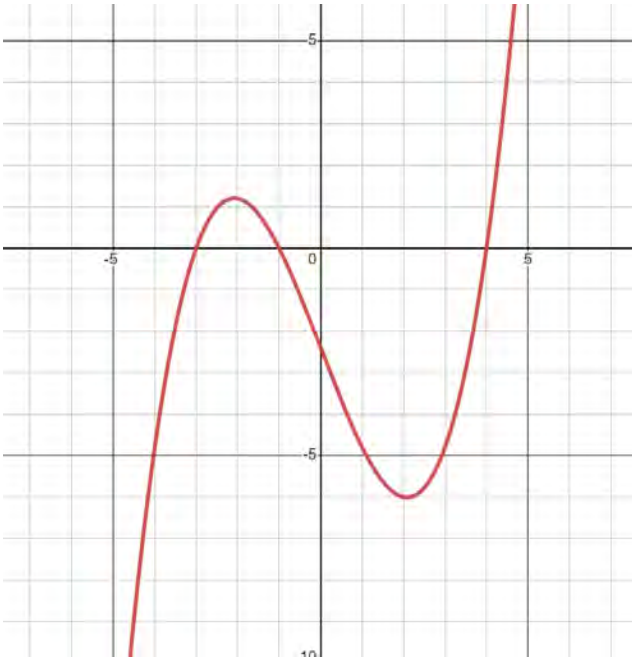
c. At what speed should you drive if you want to save on gas?

(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

D2.2 Interpret the derivative as the slope of the curve given a graph.

D2.2, v1 List the following numbers in numerical order from least to greatest. Include a brief explanation of how you determined your order. *(Objective: Interpret the derivative.)*

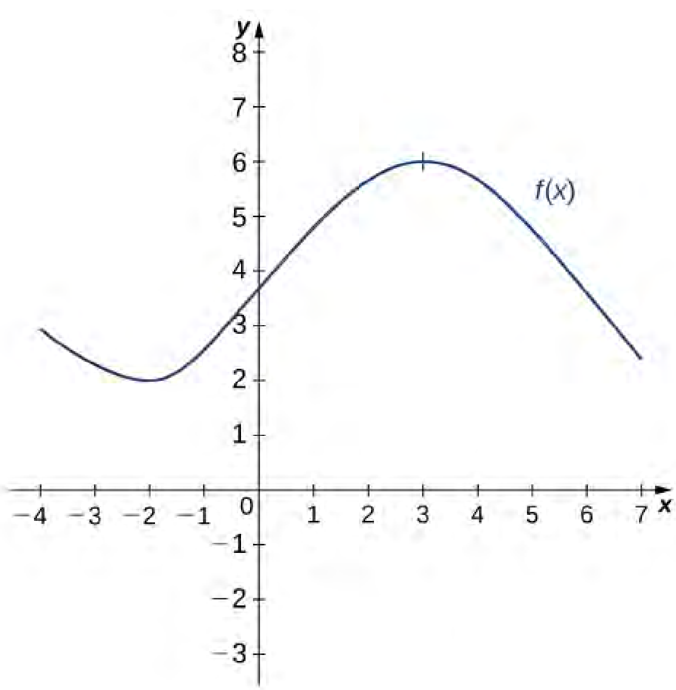
$$f'(-4)\ ,\ f'(-1),\ f'(2)$$



(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

D2.2, v2: List the following numbers in numerical order from least to greatest. Include a brief explanation of how you determined your order.

$$f'(-3)\ ,\ f'(0),\ f'(3)$$



(D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context.)

Assessment questions for D3. I can find the equation of the tangent line to a function at a point.

D3.1 Find the equation of the tangent line at a point.

D3.1, v1: Find an equation of the tangent line to the curve $y = 2e^x + x$ at the point where $x = 0$.

(D3. I can find the equation of the tangent line to a function at a point.)

D3.1, v2: Find an equation of the tangent line to the curve $y = x + \frac{1}{x}$ at the point where $x = 2$.

(D3. I can find the equation of the tangent line to a function at a point.)

D3.1, v3: Find an equation of the tangent line to the curve $y = \sqrt[4]{x} - x$ at the point where $x = 1$.

(D3. I can find the equation of the tangent line to a function at a point.)

D3.2 Find the points where the tangent line is horizontal

D3.2/D6.1, v1: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = x\sqrt{3} - 2\cos x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v2: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = 2\sin x + \sin^2 x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v3: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = e^x \cos x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v4: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = 2x + \cot x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v5: Find x values on the interval $[0, 2\pi]$ at which the tangent line to the graph of $f(x) = 4x - 3\tan x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

Assessment questions for D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.

D4.1: Derivatives using power and coefficient rule.

D4.1, v1: Find and simplify the derivative of $h(x) = \frac{x^3 - 2\sqrt{x}}{x^2}$.

(D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.1, v2: Find and simplify the derivative of $f(x) = \frac{x^4 - 5x^3 + \sqrt{x}}{x^2}$.

(D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.1, v3: Find and simplify the derivative of $f(x) = \frac{x^4 - 5x^2 + 2x}{\sqrt{x}}$.

(D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.2: Derivatives of exponentials.

D4.2/D5.1, v1: Find and simplify the derivative of $f(x) = 2e^x\sqrt{x}$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.2/D5.1, v2: Find and simplify the derivative of $f(x) = (1 - e^x)(x + e^x)$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.2/D5.1, v3: Find and simplify the second derivative of $f(x) = (x^3 + 1)e^x$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3: Derivatives of logarithms.

D4.3/D5.2, v1: Find and simplify the derivative of $h(x) = \frac{2+\ln x}{2\sqrt{x}}$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.2, v2: Find and simplify the derivative of $h(x) = \frac{\ln x}{1-x}$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.2, v3: Find and simplify the derivative of $h(x) = \frac{\ln x+1}{\ln x-1}$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.1, v4: Find and simplify the derivative of $h(x) = \sqrt{x}\ln x$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.1, v5: Find and simplify the second derivative of $f(x) =$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.1, v6: Find and simplify the second derivative of $f(x) =$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

Assessment questions for D5. I can compute derivatives using the product and quotient rules.

D5.1: Derivatives using product rule.

D4.2/D5.1, v1: Find and simplify the derivative of $f(x) = 2e^x\sqrt{x}$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.2/D5.1, v2: Find and simplify the derivative of $f(x) = (1 - e^x)(x + e^x)$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.2/D5.1, v3: Find and simplify the second derivative of $f(x) = (x^3 + 1)e^x$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.1, v4: Find and simplify the derivative of $h(x) = \sqrt{x}\ln x$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.1, v5: Find and simplify the second derivative of $f(x) =$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.1, v6: Find and simplify the second derivative of $f(x) =$

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D5.2: Derivatives using quotient rule.

D4.3/D5.2, v1: Find and simplify the derivative of $h(x) = \frac{2+\ln x}{2\sqrt{x}}$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.2, v2: Find and simplify the derivative of $h(x) = \frac{\ln x}{1-x}$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D4.3/D5.2, v3: Find and simplify the derivative of $h(x) = \frac{\ln x+1}{\ln x-1}$.

(D5. I can compute derivatives using the product and quotient rules. D4. I can compute derivatives of polynomial, exponential, and logarithmic functions.)

D6.1/D5.2, v6: Find and simplify the derivative of $f(\theta) = \frac{\cos\theta}{1-\sin\theta}$.

(D5. I can compute derivatives using the product and quotient rules. D6. I can compute derivatives of trigonometric and inverse trigonometric functions.)

D6.1/D5.2, v7: Find and simplify the derivative of $f(\theta) = \frac{\cot\theta}{e^{\theta}}$.

(D5. I can compute derivatives using the product and quotient rules. D6. I can compute derivatives of trigonometric and inverse trigonometric functions.)

D6.1/D5.2, v8: Find the derivative of $f(x) = \tan x$ by writing the function in terms of $sine$ and $cosine$ first and then using the quotient rule.

(D5. I can compute derivatives using the product and quotient rules. D6. I can compute derivatives of trigonometric and inverse trigonometric functions.)

Assessment questions for D6. I can compute derivatives of trigonometric and inverse trigonometric functions.

D6.1: Derivatives of trigonometric functions.

D3.2/D6.1, v1: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = x\sqrt{3} - 2\cos x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v2: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = 2\sin x + \sin^2 x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v3: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = e^x \cos x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v4: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = 2x + \cot x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D3.2/D6.1, v5: Find x values on the interval [0, 2π] at which the tangent line to the graph of $f(x) = 4x - 3\tan x$ is horizontal.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions.)

D6.1/D5.2, v6: Find and simplify the derivative of $f(\theta) = \frac{\cos\theta}{1-\sin\theta}$.

(D5. I can compute derivatives using the product and quotient rules. D6. I can compute derivatives of trigonometric and inverse trigonometric functions.)

D6.1/D5.2, v7: Find and simplify the derivative of $f(\theta) = \frac{\cot\theta}{e^{\theta}}$.

(D5. I can compute derivatives using the product and quotient rules. D6. I can compute derivatives of trigonometric and inverse trigonometric functions.)

Assessment questions for D6. I can compute derivatives of trigonometric and inverse trigonometric functions.

D6.1/D5.2, v8: Find the derivative of $f(x) = \tan x$ by writing the function in terms of $sine$ and $cosine$ first and then using the quotient rule.

(D5. I can compute derivatives using the product and quotient rules. D6. I can compute derivatives of trigonometric and inverse trigonometric functions.)

D6.2: Derivatives of inverse trigonometric functions.

D6.2/D7.1, v1: Find and simplify the derivative of $f(x) = \arcsin\left(\frac{1}{x}\right)$.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

D6.2/D7.1, v2: Find and simplify the derivative of $f(x) = \tan^{-1}(x^2)$.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

D6.2/D7.1, v3: Find the equation of the tangent line to the graph of $g(x) = \tan^{-1}\sqrt{x}$ at the point where $x = 3$. Use exact values for x and y, and radians for y.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

D6.2/D7.1, v4: Find and simplify the derivative of$h(x) = \arccos\sqrt{x}$.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

Assessment questions for D7. I can compute derivatives of composite functions using the Chain Rule.

D7.1: Chain rule involving inverse trigonometric functions.

D6.2/D7.1, v1: Find and simplify the derivative of $f(x) = \arcsin\left(\frac{1}{x}\right)$.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

D6.2/D7.1, v2: Find and simplify the derivative of $f(x) = \tan^{-1}(x^2)$.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

D6.2/D7.1, v3: Find the equation of the tangent line to the graph of $g(x) = \tan^{-1}\sqrt{x}$ at the point where $x = 3$. Use exact values for x and y, and radians for y.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

D6.2/D7.1, v4: Find and simplify the derivative of$h(x) = \arccos\sqrt{x}$.

(D6. I can find the compute derivatives of trigonometric and inverse trigonometric functions. D7. I can compute derivatives of composite functions using the Chain Rule.)

D7.2: Chain rule involving inverse logarithmic functions.

D7.2, v1: Find and simplify the derivative of $h(x) = \ln(xe^{-2x})$.

(D7. I can compute derivatives of composite functions using the Chain Rule.)

D7.2, v2: Find and simplify the derivative of $g(x) = \ln(\cos^2 x)$.

(D7. I can compute derivatives of composite functions using the Chain Rule.)

D7.3: Chain rule involving inverse radical/power functions.

D7.3, v1: Find and simplify the derivative of $g(x) = x^2\sqrt{x^3+1}$.

Assessment questions for D7. I can compute derivatives of composite functions using the Chain Rule.

(D7. I can compute derivatives of composite functions using the Chain Rule.)

D7.3, v2:   Find and simplify the derivative of $g(x) = \frac{x^2}{\sqrt{x^3+1}}$.

(D7. I can compute derivatives of composite functions using the Chain Rule.)

D7.3, v3:   Find and simplify the derivative of $g(x) = \sqrt{\frac{x}{x+1}}$.

(D7. I can compute derivatives of composite functions using the Chain Rule.)

D7.4: Chain rule involving functions.

D7.4, v1:   Find and simplify the derivative of .

(D7. I can compute derivatives of composite functions using the Chain Rule.)

Assessment questions for D8. I can compute the derivative of an implicitly defined function using implicit differentiation.

D8, v1: Find and simplify $\frac{dy}{dx}$: $xe^y = x - y$.

(D8. I can compute the derivative of an implicitly defined function using implicit differentiation.)

D8, v2: Find and simplify $\frac{dy}{dx}$: $2x^2 + xy - y^2 = 2x$

(D8. I can compute the derivative of an implicitly defined function using implicit differentiation.)

D8, v3: Find and simplify $\frac{dy}{dx}$: $\frac{x^2}{x+y} = y^2 + 1$

(D8. I can compute the derivative of an implicitly defined function using implicit differentiation.)

D8, v4: Find all points where the tangent line to the curve $y = x^2 + xy + y^2 = 1$ is parallel to the line $y = -x$.

(D8. I can compute the derivative of an implicitly defined function using implicit differentiation.)

D8, v5: Find and simplify the derivative of .

(D8. I can compute the derivative of an implicitly defined function using implicit differentiation.)

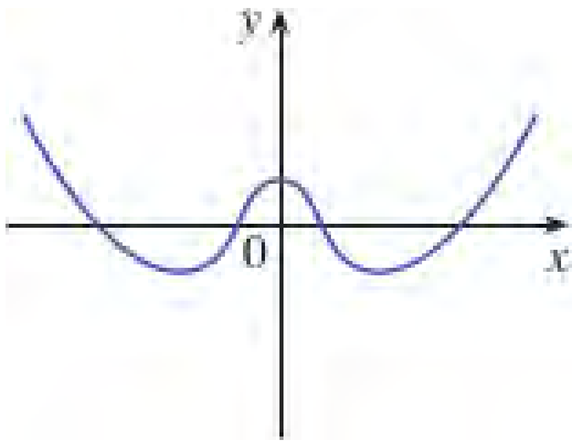
D8, v6: Find and simplify the derivative of .

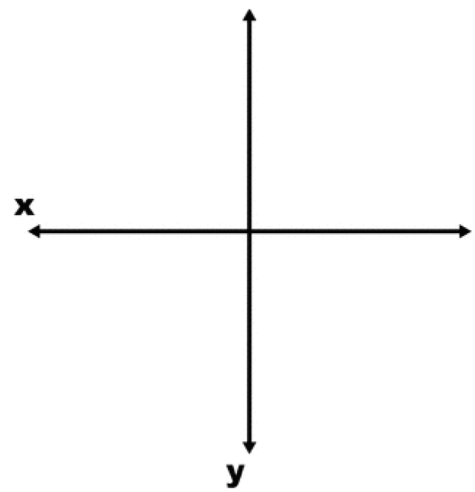
(D8. I can compute the derivative of an implicitly defined function using implicit differentiation.)

Assessment questions for A1. I can sketch f, f', or f'' given a graph of f, f', or f''.

A1.1 Sketch the graph of the derivative of a given graph.

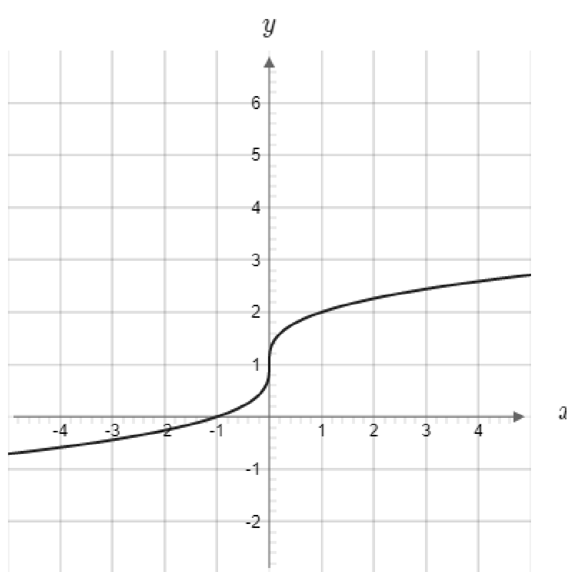
A1.1, v1: The graph of a function is shown. Sketch a graph of it's derivative on the axes next to it.

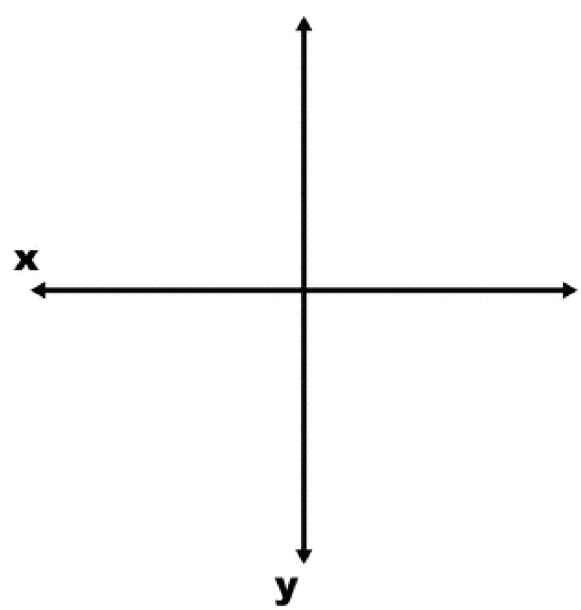




(A1. I can sketch f, f', or f'' given a graph of f, f', or f''.)

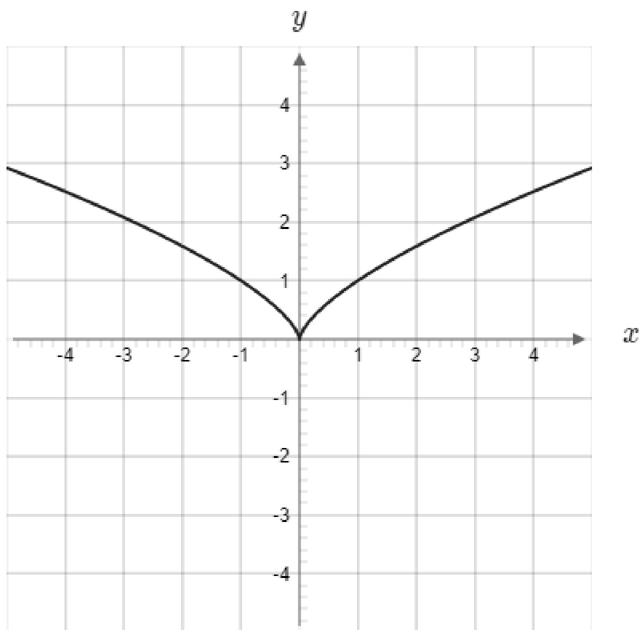
A1.1, v2: The graph of a function is shown. Sketch a graph of it's derivative on the axes next to it.

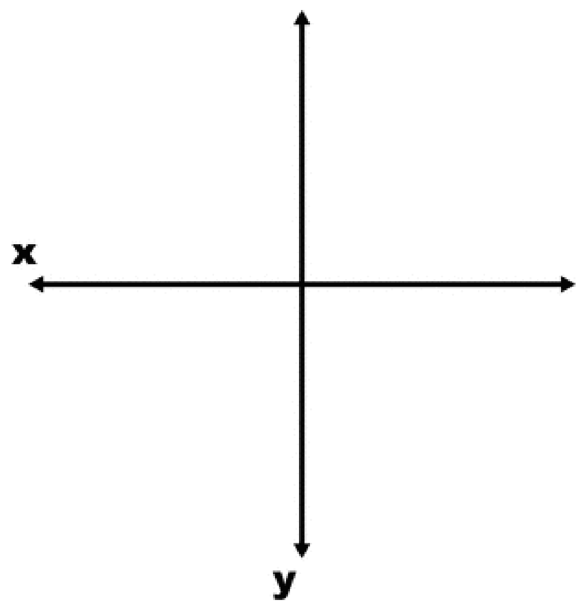




(A1. I can sketch f, f', or f'' given a graph of f, f', or f''.)

A1.1, v3: The graph of a function is shown. Sketch a graph of it's derivative on the axes next to it.

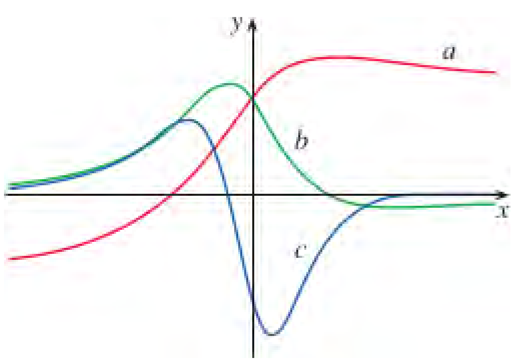




(A1. I can sketch f, f', or f'' given a graph of f, f', or f''.)

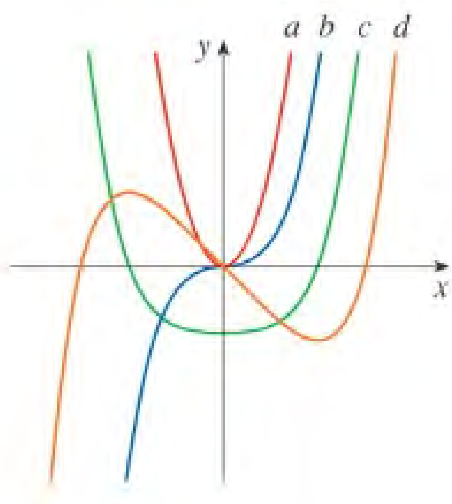
A1.2 Given three graphs, identify f, f' and f''.

A1.2, v1: The figure shows the graphs of f, f', and f''. Identify each curve and explain your choices.



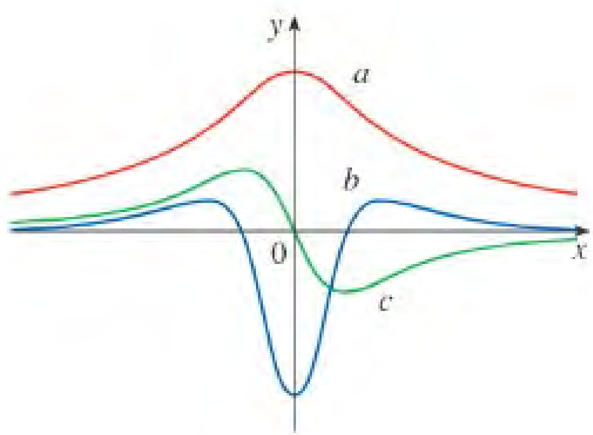
(A1. I can sketch f, f', or f'' given a graph of f, f', or f''.)

A1.2, v2: The figure shows the graphs of f, f', f'', and f'''. Identify each curve and explain your choices.



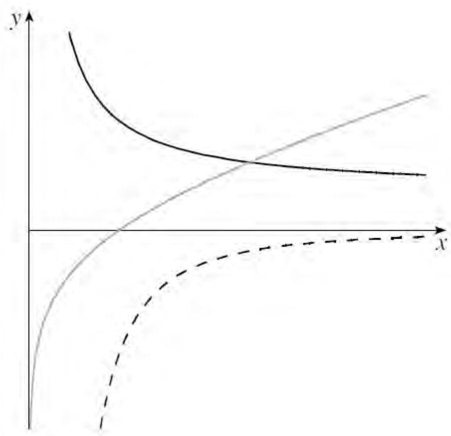
(A1. I can sketch f, f', or f'' given a graph of f, f', or f''.)

A1.2, v3: The figure shows the graphs of f, f', f'', and f'''. Identify each curve and explain your choices.



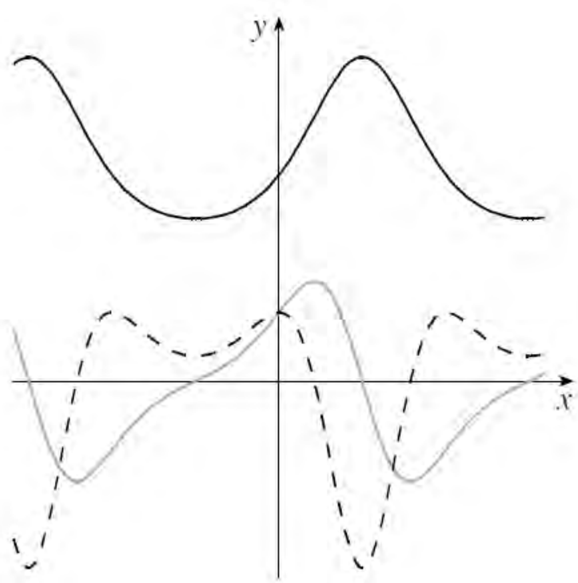
(A1. I can sketch f, f', or f'' given a graph of f, f', or f''.)

A1.2, v4: The figure shows the graphs of f, f', f'', and f'''. Identify each curve and explain your choices.



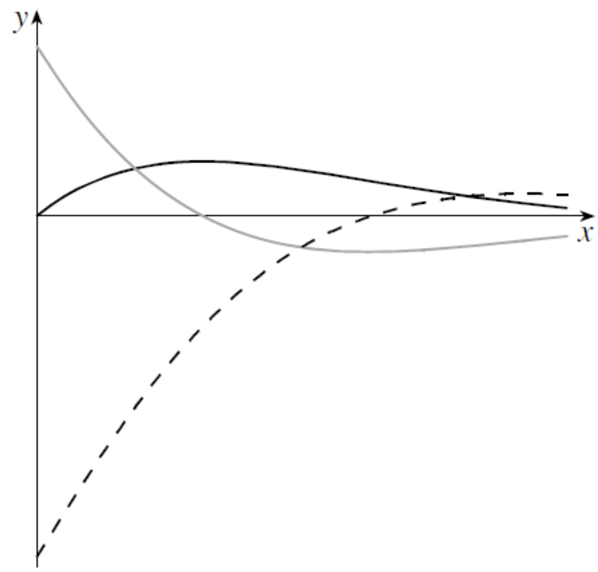
(A1. I can sketch $f, f', \text{or } f''$ given a graph of $f, f', \text{or } f''$.)

A1.2, v5: The figure shows the graphs of f, f', f'', and f'''. Identify each curve and explain your choices.



(A1. I can sketch $f, f', \text{or } f''$ given a graph of $f, f', \text{or } f''$.)

A1.2, v6: The figure shows the graphs of f, f', f'', and f'''. Identify each curve and explain your choices.



(A1. I can sketch f, f', or f'' given a graph of f, f', or f''.)

Assessment questions for A2. I can use derivatives to solve problems in the natural and social sciences.

A2.1 Motion Analysis

A2.1, v1: The position of a particle is given by $s(t) = t^2 e^{-t}$, where t is measured in seconds and s in feet.

a) When is the particle moving forward (that is, in the positive direction?)
b) Draw a diagram to represent the motion of the particle.
c) Find the total distance traveled by the particle during the first 6 seconds.
d) When is the particle speeding up and slowing down?

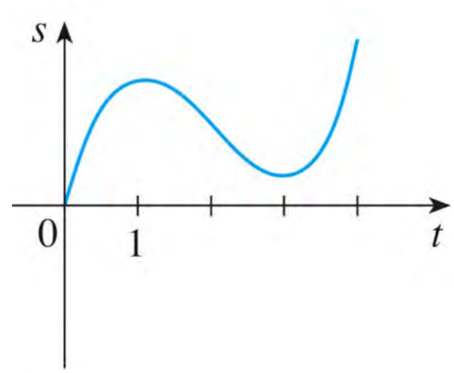
(A2. I can use derivatives to solve problems in the natural and social sciences.)

A2.1, v2: The position of a particle is given by $s(t) = e^t(5 - t) - 5$, where t is measured in seconds and s in feet.

a) When is the particle moving forward (that is, in the positive direction?)
b) Draw a diagram to represent the motion of the particle.
c) Find the total distance traveled by the particle during the first 8 seconds.
d) When is the particle speeding up and slowing down?

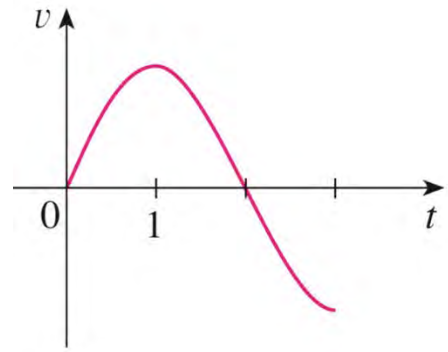
(A2. I can use derivatives to solve problems in the natural and social sciences.)

A2.1, v3: The graph of the position function of a particle is shown as a function of time. When is the particle speeding up? When is the particle slowing down? Explain.



(A2. I can use derivatives to solve problems in the natural and social sciences.)

A2.1, v4: The graph of the velocity function of a particle is shown as a function of time. When is the particle speeding up? When is the particle slowing down? Explain.



(A2. I can use derivatives to solve problems in the natural and social sciences.)

A2, v6:

(A2. I can use derivatives to solve problems in the natural and social sciences.)

Assessment questions for A3. I can use derivatives to solve problems involving related rates of change.

A3, v1: A brewer uses an inverted conical tank (a cone with the point down) to ferment his beer. His tank measures 10 feet across the top and is 12 feet deep. If beer is flowing into the tank at a rate of 10 cubic feet per minute, find the rate of change of the depth of the beer when the beer is 8 feet deep. (Volume of a cone is given be the equation $V = \frac{\pi}{3}r^2h$.)

(A3. I can use derivatives to solve problems involving related rates of change.)

A3, v2: A 6-foot-tall person is walking towards a 16-foot pole at a rate of 4 ft/sec. Assume the scenario can be modeled with right triangles. At what rate is the length of the person's shadow changing when the person is 8 feet from the lamppost?

(A3. I can use derivatives to solve problems involving related rates of change.)

A3, v3: A conical paper cup is 10 cm tall with a radius of 10 cm. The bottom of the cup is punctured so that the water level goes down at a rate of 2 cm/sec. At what rate is the volume of water in the cup changing when the water level is 9 cm? (Volume of a cone is given by the equation $V = \frac{\pi}{3}r^2h$)

(A3. I can use derivatives to solve problems involving related rates of change.)

A3, v4: Two airplanes fly eastward on parallel courses 12 miles apart. One flies at 240 mph and the other at 300 mph. How fast is the distance between them changing when the slower plane is 5 miles farther east than the faster plane?

(A3. I can use derivatives to solve problems involving related rates of change.)

A3, v5: A barge whose deck is 5 meters below the level of a dock is being drawn in by means of a cable attached to the dock and passing through a ring on the dock. When the barge is 12 meters away and approaching the dock at $\frac{3}{4}$ meters per minute, how fast is the cable being pulled in?

(A3. I can use derivatives to solve problems involving related rates of change.)

A3, v6: A ladder rests against a vertical pole. The foot of the ladder is sliding away from the pole along horizontal ground. Find the inclination of the ladder to the horizontal at the instant when the top of the ladder is moving 3 times as fast as the foot of the ladder.

(A3. I can use derivatives to solve problems involving related rates of change.)

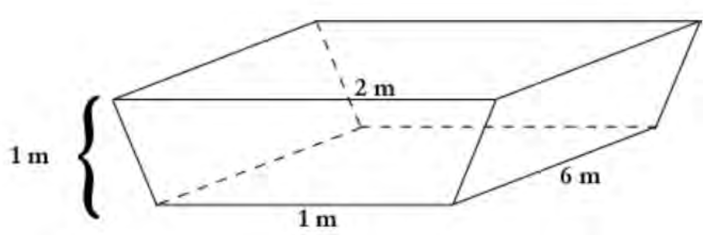
A3, v7: Two points, A and B, are 275 feet apart. At a given instant, a balloon is released at B and rises vertically at a constant rate of 2.5 ft/s. At the same instant, a cat starts running from A to B at a constant rate of 5 ft/s.

a. After 40 seconds, is the distance between the cat and the balloon decreasing or increasing? At what rate?

b. Describe what is happening to the distance and the balloon at $t = 50$ seconds.

(A3. I can use derivatives to solve problems involving related rates of change.)

A3, v8: The cross section of a trough is a trapezoid with lower base 1 meter, upper base 2 meters, and depth 1 meter. The length of the trough is 6 meters. If water is poured in at a rate of 12 cubic meters per minute, at what rate is the water rising when the depth of the water is $\frac{1}{3}$ meters?



the diagram shown above is not to scale

(A3. I can use derivatives to solve problems involving related rates of change.)

Assessment questions for A4. I can find all critical points, local extrema, and inflection points of a given function.

A4.1 Find Critical Numbers, classify as max, min, or neither from equation

A4.1, v1: Let $f(x) = x^{\frac{1}{3}}(x+4)$. Find all the critical number of $f(x)$ and classify them as relative maximums, relative minimums, or neither.

(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.1, v2: Let $f(x) = x^{\frac{4}{5}}(x-4)^2$. Find all the critical numbers of $f(x)$ and classify them as relative maximums, relative minimums, or neither.

(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.1, v3: Let $f(x) = x^{\frac{1}{4}}(\sqrt{x}-2)$. Find all the critical numbers of $f(x)$ and classify them as relative maximums, relative minimums, or neither.

(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.2 Find Inflection Points from equation

A4.2, v1: Without graphing the function, find any inflection points of $f(x) = \frac{3(x+1)^2}{(x-1)^2}$.

(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.2, v2: Without graphing the function, find any inflection points of $f(x) = \frac{x^3}{1+x^2}$.

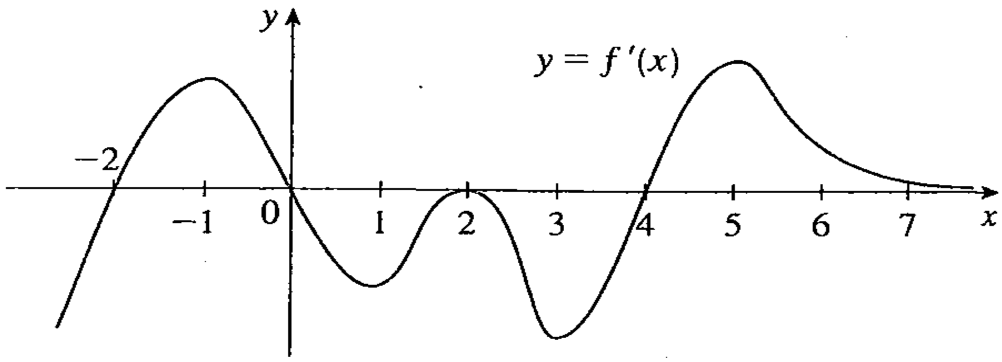
(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.2, v3: Without graphing the function, find any inflection points of $f(x) = \frac{(x+1)^2}{1+x^2}$.

(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.3 Extrema and inflection points from graph of derivative

A4.3, v1: Below is the graph of the derivative of a function f, that is, it is the graph of $f'(x)$. Answer each of the following questions based on this graph. **Provide justification with each answer.**

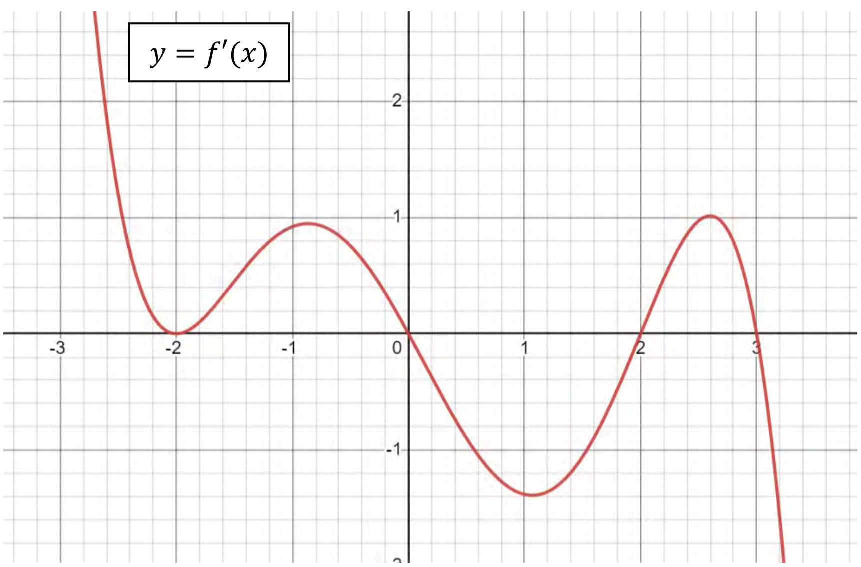


a) At what x values, if any, are local extrema of the graph of $f(x)$ located?

b) At what x values, if any, are the inflection points of the graph of $f(x)$ located?

(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.3, v2: Below is the graph of the derivative of a function f, that is, it is the graph of $f'(x)$. Answer each of the following questions based on this graph. **Provide justification with each answer.**



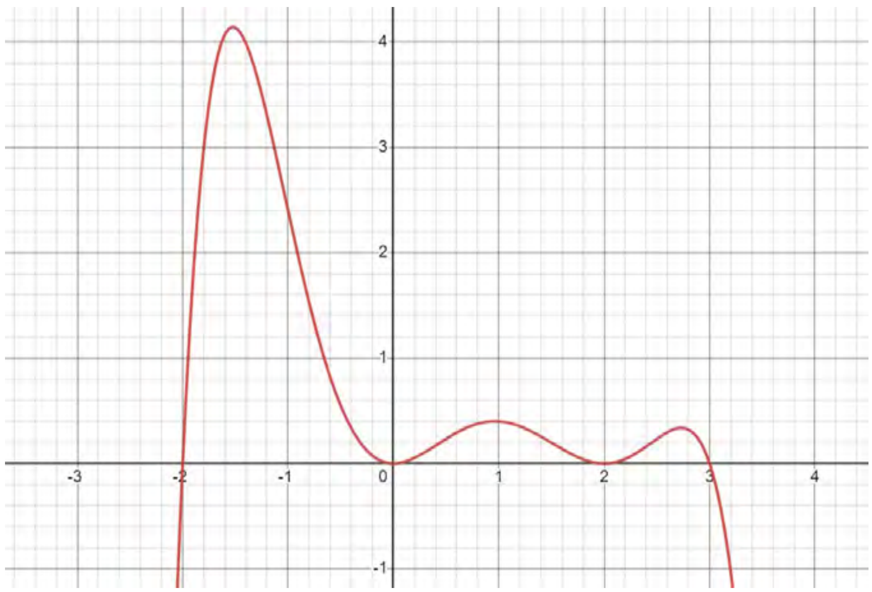
a) At what x values, if any, are local extrema of the graph of $f(x)$ located?

b) At what x values, if any, are the inflection points of the graph of $f(x)$ located?

(A4. I can find all critical points, local extrema, and inflection points of a given function.)

A4.3, v3: Below is the graph of the derivative of a function f, that is, it is the graph of $f'(x)$. Answer each of the following questions based on this graph. **Provide justification with each answer.**

$y = f'(x)$



a) At what x values, if any, are local extrema of the graph of $f(x)$ located?

b) At what x values, if any, are the inflection points of the graph of $f(x)$ located?

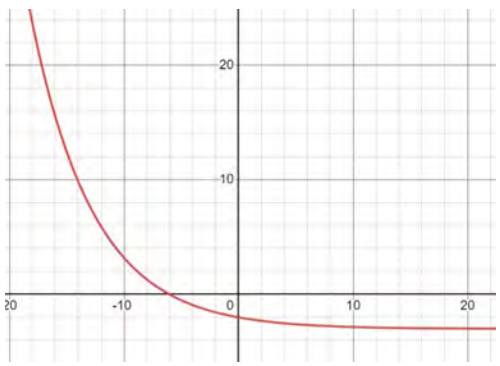
(A4. I can find all critical points, local extrema, and inflection points of a given function.)

Assessment questions for A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function.

A5.1 Describe relationship between first derivative, second derivative, and graph of function.

A5.1, v1: The graph of $f(x)$ is shown. Identify each of the following statements as true or false, and provide a reason for each selection.

(Objective: Describe the relationship between the first derivative, second derivative, and the graph of the function)



a. $f(x)$ is negative

b. $f(x)$ is decreasing

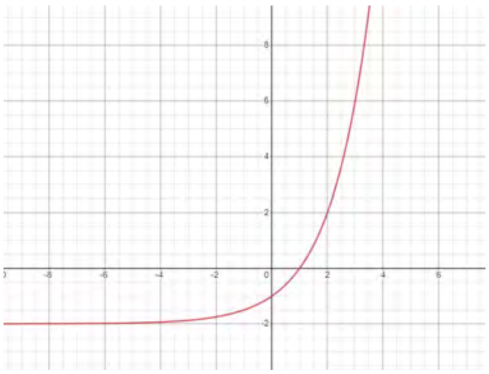
c. $f'(x)$ is negative

d. $f'(x)$ is decreasing

e. $f''(x)$ is negative

(A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function.)

A5.1, v2: The graph of $f(x)$ is shown. Identify each of the following statements as true or false, and provide a reason for each selection.



a. $f(x)$ is positive

b. $f(x)$ is increasing

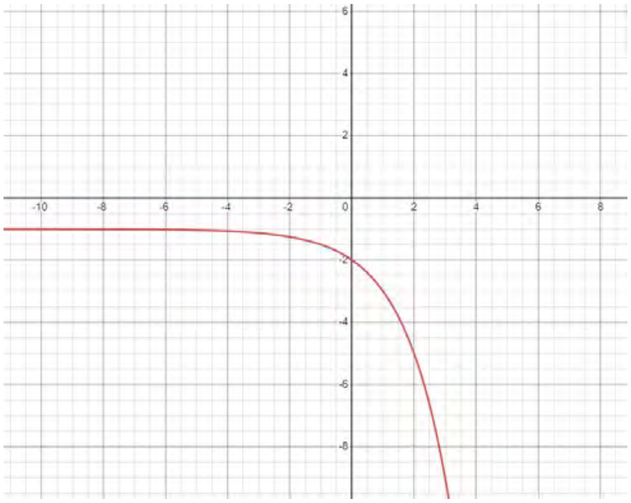
c. $f'(x)$ is positive

d. $f'(x)$ is decreasing

e. $f''(x)$ is negative

(A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function.)

A5.1, v3: The graph of $f(x)$ is shown. Identify each of the following statements as true or false, and provide a reason for each selection.



a. $f(x)$ is negative

b. $f(x)$ is decreasing

c. $f'(x)$ is negative

d. $f'(x)$ is decreasing

e. $f''(x)$ is negative

(A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function.)

A5.2 Sketch graph given info on derivative and limits

A5.2, v1: Sketch the graph of a continuous function, f, that satisfies the following conditions:

f is odd,

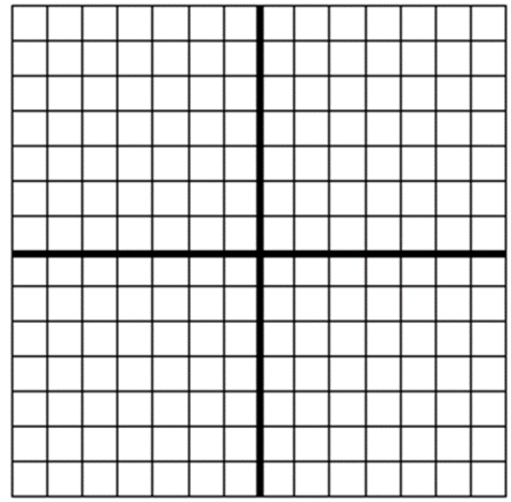
$f'(x) < 0$ for $0 < x < 2$,

$f'(x) > 0$ for $x > 2$,

$f''(x) > 0$ for $0 < x < 3$

$f''(x) < 0$ for $x > 3$,

$\lim_{x \to \infty} f(x) = -2$



(A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function.)

A5.2, v2: Sketch the graph of a continuous function, f, that satisfies the following conditions:

$f'(0) = f'(4) = 0$

$f'(x) = 1$ if $x < -1$,

$f'(x) > 0$ if $0 < x < 2$,

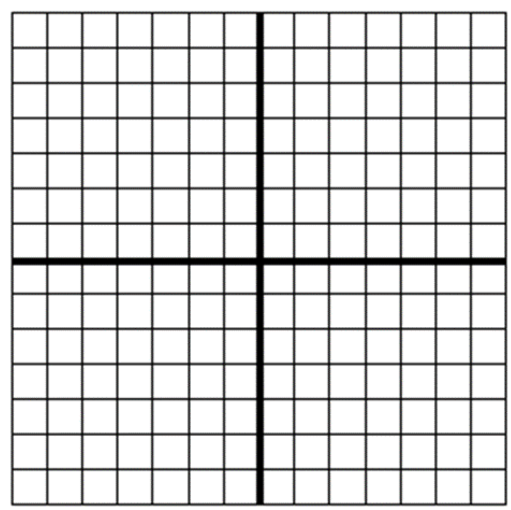
$f'(x) < 0$ if $-1 < x < 0$ or $2 < x < 4$ or $x > 4$,

$f''(x) > 0$ if $-1 < x < 2$ or $2 < x < 4$

$f''(x) < 0$ if $x > 4$,

$\lim_{x \to 2^-} f'(x) = \infty$

$\lim_{x \to 2^+} f'(x) = -\infty$



(A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function.)

A5.2, v3: Sketch the graph of a continuous function, f, that satisfies the following conditions:

$f'(4) = 0$

$f'(x) > 0$ if $x > 4$,

$f'(x) < 0$ if $x < 4$

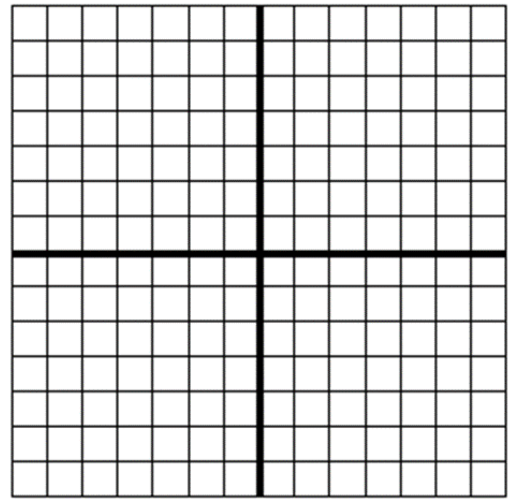
$f''(2) = f''(6) = 0$

$f''(x) > 0$ if $2 < x < 6$

$f''(x) < 0$ if $x < 2$ or $x > 6$,

$\lim_{x \to \infty} f(x) = 3$

$\lim_{x \to -\infty} f(x) = 3$



(A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function.)

Assessment questions for A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.

A6.1: Absolute extrema of continuous function on closed interval

A6.1, v1: Find the exact values of all absolute extrema for $g(x) = 2\sec x - \tan x$ on the interval $[0, \frac{\pi}{4}]$.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.1, v2: Find the exact values of all absolute extrema for $f(x) = x^3 e^{-x}$on the interval $[-2, 6]$.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.1, v3: Find the exact values of all absolute extrema for $f(x) = \sin^2 x$ on the interval $[0, \pi]$.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.1, v4: Find the exact values of all absolute extrema for $f(x) = x + \cot\left(\frac{x}{2}\right)$ on the interval $\left[\frac{\pi}{4}, \frac{7\pi}{4}\right]$.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.1, v5: Find the exact values of all absolute extrema for $g(x) = x\sqrt{1-x}$ on the interval $[-1,1]$.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.1, v6: Find the exact values of all absolute extrema for $g(x) = x\sqrt{1-x^2}$ on the interval $[-1,1]$.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.1, v7: Find the exact values of all absolute extrema for $g(x) = x\sqrt{2 - x^2}$ on the interval $[-\sqrt{2}, \sqrt{2}]$.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.2 Solve optimization problems

A6.2, v1: A box with a square base is taller than it is wide. In order to send the box through the U.S. mail, the height of the box and the perimeter of the base of the box can sum to no more than 108 inches. What is the maximum volume for such a box?

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.2, v2: The top and bottom margins of a poster are each 6 cm and the side margins are each 4cm. If the area of the printed material on the poster is fixed at 384 square cm, find the dimensions of the poster with the smallest area.

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.2, v3: A poster is to have an area of 180 square inches with 1-inch margins and the bottom and sides and a 2-inch margin at the top. What dimensions will give the largest printed area?

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.2, v4: A supermarket employee wants to construct an open-top box from a 14 by 30 inch piece of cardboard. To do this, the employee plans to cut out squares of equal size from the four corners so the four sides can be bent upwards. What size should the square be in order to create a box with the largest possible volume?

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

A6.2, v5: Two vertical poles, one 16 ft high and the other 24 ft high, stand 30 feet apart on a flat field. A worker wants to support both poles by running wire from the group to the top of each post. If the worker wants to stake both wires in the ground at the same point, where should the stake be places to use the least amount of rope?

(A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems.)

Assessment questions for I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives.

I1.1: General antiderivative

I1.1, v1: Find the general antiderivative of $g(x) = \frac{2x-5}{\sqrt{x}}$.

(I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives.)

I1.1, v2: Find the general antiderivative of $f(x) = x(2-x)^2$.

(I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives.)

I1.1, v3: Find the general antiderivative of $h(x) = \sqrt[3]{x^2} - \frac{3}{x^3}$.

(I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives.)

I1.2: Particular antiderivative with initial condition.

I1.2, v1: Find f if $f'(x) = \frac{4}{\sqrt{1-x^2}}$, $f\left({}^{1}/_{2}\right) = 1$.

(I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives.)

I1.2, v2: A particle is moving with velocity function $v(t) = t^2 - 3\sqrt{t}$. Find the position function of the particle if $s(4) = 8$.

(I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives.)

I1.2, v3: Find f if $f'(x) = \sec x\,(\sec x + \tan x)$, $-\frac{\pi}{2} < x < \pi/1$, and $f\left({}^{\pi}/_{4}\right) = -1$.

(I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives.)

Assessment questions for I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.

I2.1: Find area under curve using limits of Riemann sums.

I2.1, v1: Use the **definition** of area under a curve (this means the limit of a sum) to find the area under $f(x) = x^2 - x$ on the interval [2, 3].

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.1, v2: Use the **definition** of area under a curve (this means the limit of a sum) to find the area under $f(x) = 2x - x^3$ on the interval [-2, 0].

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.1, v3: Use the **definition** of area under a curve (this means the limit of a sum) to find the area under $f(x) = x^2 - 4x + 2$ on the interval [4, 8].

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.2: Setup limit of Riemann sums that defines area; do not evaluate.

I2.2, v1: Use the definition of area to find an expression for the area under the graph of f as a limit. Do not evaluate the limit.

$$f(x) = \frac{x}{x^2 - 1}, \qquad 1 \leq x \leq 3$$

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.2, v2: Use the definition of area to find an expression for the area under the graph of f as a limit. Do not evaluate the limit.

$$f(x) = \sqrt{4x + 7}, \qquad 0 \leq x \leq 5$$

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.2, v3: Use the definition of area to find an expression for the area under the graph of f as a limit. Do not evaluate the limit.

$$f(x) = \cos\sqrt{x}\,, \qquad 1 \le x \le \frac{\pi^2}{4}$$

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.3: Use limit of Riemann sum to identify region whose area is specified.

I2.3, v1: Determine a region whose area is equal to the given limit. Do not evaluate the limit.

a. $\lim\limits_{n\to\infty} \sum_{i=1}^{n} \frac{1}{n} e^{1+\frac{i}{n}}$

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.3, v2: Determine a region whose area is equal to the given limit. Do not evaluate the limit.

a. $\lim\limits_{n\to\infty} \sum_{i=1}^{n} \frac{3}{n} \sqrt{7 + \frac{3i}{n}}$

(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

I2.3, v3: Determine a region whose area is equal to the given limit. Do not evaluate the limit.

a. $\lim\limits_{n\to\infty} \sum_{i=1}^{n} 2\left(\frac{5i}{n}\right)\left(\frac{5}{n}\right)$

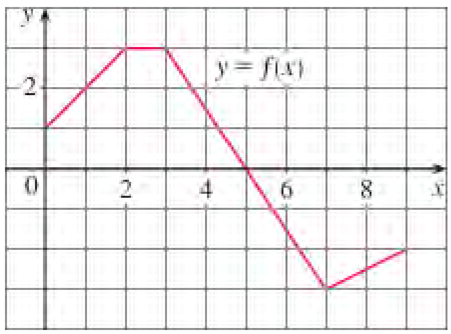
(I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals.)

Assessment questions for I3. I can evaluate definite integrals using only simple geometric formulas.

I3, v1: Draw a picture of and *clearly* shade in the region whose area is represented by the following definite integral: $\int_0^4 (2x-1)dx$. Calculate the net area using geometry.

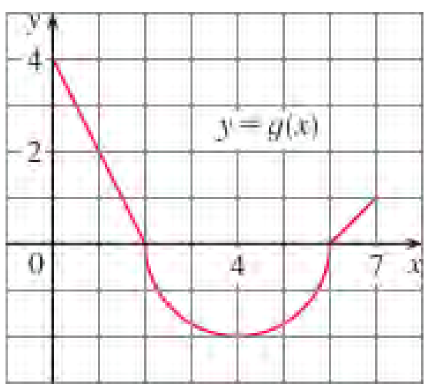
(I3. I can evaluate definite integrals using only simply geometric formulas.)

I3, v2: The graph of f is shown. Evaluate $\int_0^5 f(x)\ dx$ by interpreting it in terms of area.



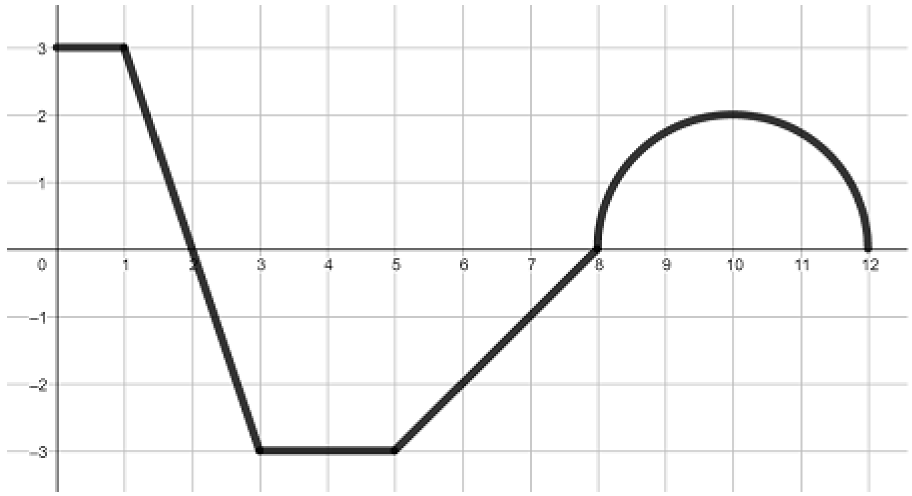
(I3. I can evaluate definite integrals using only simply geometric formulas.)

I3, v3: The graph of g is shown. Evaluate $\int_2^6 g(x)\ dx$ by interpreting it in terms of area.



(I3. I can evaluate definite integrals using only simply geometric formulas.)

Other graphs: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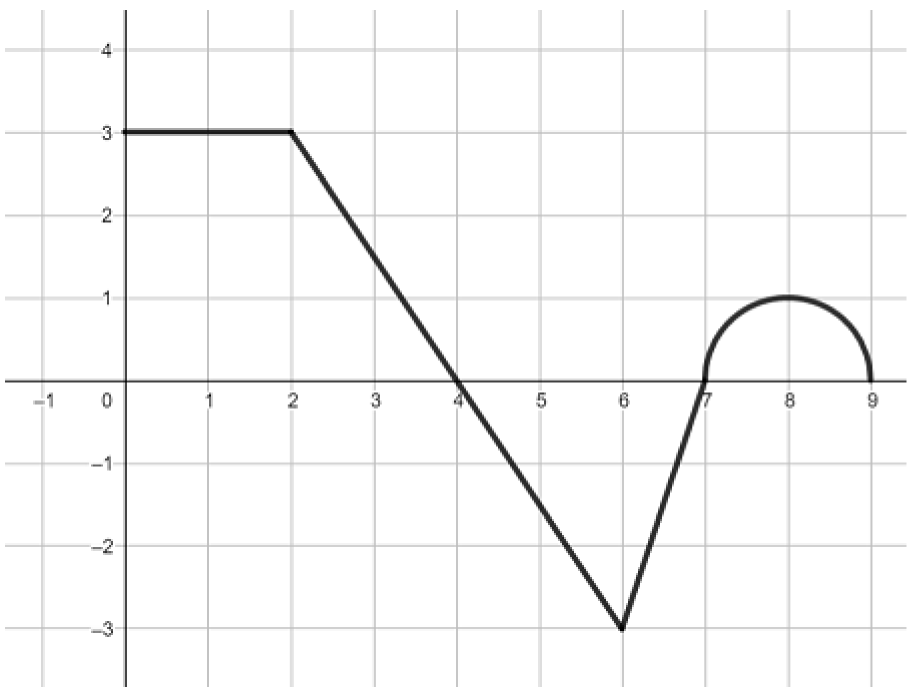
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Assessment questions for I4. I can evaluate definite integrals using the Fundamental Theorem of Calculus.

I4, v1: Evaluate: $\int_1^4 \frac{2x^3+x^2}{x^4}\, dx$.

(I4. I can evaluate definite integrals using the Fundamental Theorem of Calculus.)

I4, v2: Evaluate: $\int_1^4 (8-t)t^{2/3}\, dt$.

(I4. I can evaluate definite integrals using the Fundamental Theorem of Calculus.)

I4, v3: Evaluate: $\int_{\frac{1}{\sqrt{3}}}^{\sqrt{3}} \frac{5}{1+x^2}\, dx$.

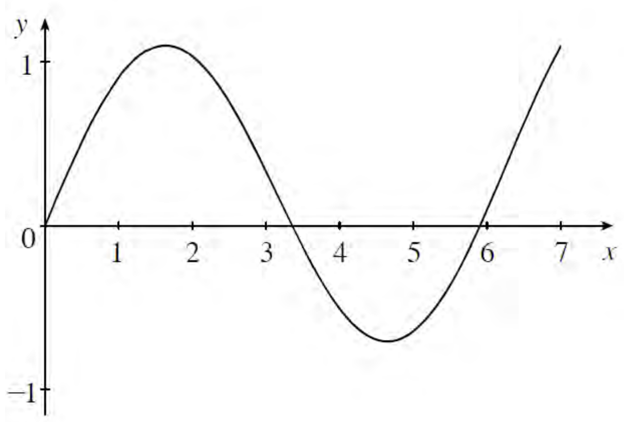
(I4. I can evaluate definite integrals using the Fundamental Theorem of Calculus.)

Assessment questions for I5. I can use definite integrals to measure change.

I5, v1: The velocity of a particle is given by $v(t) = 3t - t^2$. Find the displacement of the particle and the total distance travelled by a particle in the first four seconds of motion.

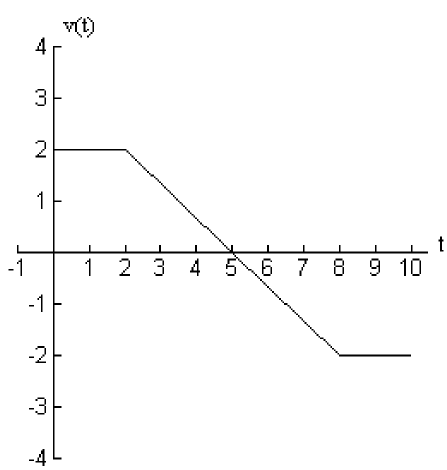
(I5. I can use definite integrals to measure change.)

I5, v2: Below is the graph of a hot air balloon's vertical velocity v versus time t for $0 \leq t \leq 7$. Did the balloon every drop below its starting height during this time? Justify your answer.



(I5. I can use definite integrals to measure change.)

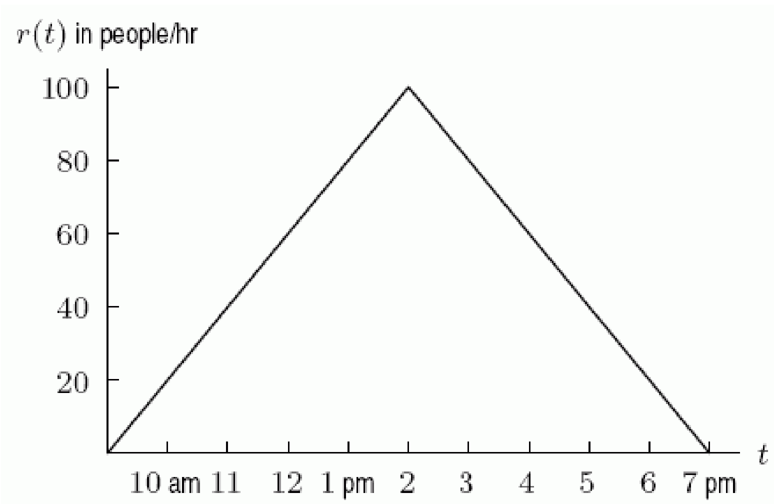
I5, v3: A particle is traveling along a straight line. (Positive velocities indicate movement to the right.) What is the change in position from the particle's starting point when t = 8? Is the change in position equal to the total distance traveled in the first 8 seconds? Why or why not?



(I5. I can use definite integrals to measure change.)

Assessment questions for I5. I can use definite integrals to measure change.

I5, v4: A shop is open from 9am-7pm. The function *r*(*t*), graphed below, gives the rate at which customers arrive (in people/hour) at time *t*. Suppose that the salespeople can serve customers at a rate of 80 people per hour. When is the line the longest? Answer to the nearest half-hour.



(I5. I can use definite integrals to measure change.)

Assessment questions for I6. I can evaluate integrals using the substitution method.

I6, v1: Evaluate the integral: $\int_0^1 \left(\frac{x}{x^2-4}\right) \, dx$

(I6. I can evaluate integrals using the substitution method.)

I6, v2: Evaluate the integral: $\int \frac{\sin\sqrt{x}}{\sqrt{x}} \, dx$

(I6. I can evaluate integrals using the substitution method.)

I6, v3: Evaluate the integral: $\int \frac{(5+\ln x)^5}{x} \, dx$

(I6. I can evaluate integrals using the substitution method.)

I6, v4: Evaluate $\int_0^{\pi/6} \left(\frac{\sin t}{\cos^2 t}\right) \, dt$

(I6. I can evaluate integrals using the substitution method.)

I6, v5: Evaluate the integral: $\int \frac{8e^{-3+\ln 3x}}{x} \, dx$

(I6. I can evaluate integrals using the substitution method.)

I6, v6: Evaluate the integral: $\int x^3 \sec^2(4x^4 - 2) \, dx$

(I6. I can evaluate integrals using the substitution method.)

I6, v7: Evaluate $\int \left(\frac{x}{1+x^4}\right) \, dx$

(I6. I can evaluate integrals using the substitution method.)

Assessment Grading Details: Math 192

Every three weeks there will be an in-class assessment, giving you the first opportunity to demonstrate successful attempts on problems covering objectives from the previous weeks. Every problem will be evaluated using one of the following marks:

- **Successful**
  - This mark indicates that you have demonstrated mastery on the problem. This mark will count as one of the successful demonstrations needed to earn full mastery of the assessed objective.

- **Minor Revisions Needed**
  - This mark indicates that your work may contain a small arithmetic error, miscopied value, or similar error that is important to fix, but is not central to your understanding of the objective.
  - You have 3 days (beginning on the day the assessment is returned – that day counts as day 1) to submit a "Revision Form" in which you explain the error and how to correct it. You must upload the form to the Canvas assignment for that assessment. Late Revision Forms are not accepted. Blank Revision Forms can be found in the Course Information module in our Canvas course. If the form is filled out to my satisfaction, your mark will be upgraded to "Successful".

- **New Attempt Required**
  - This mark indicates that you have made at least one critical error in your work, and mastery is not possible on this attempt.
  - To achieve mastery, you must reattempt on a new problem on the same outcome, which will be marked using the same scale and process.

- For each problem that is not marked successful, feedback will also be provided to guide you to further understanding of the concept.
- You can **request 2 New Attempts per week** in Student Hours
  - In order to given a New Attempt at mastery on an objective's assessment, you must submit a thorough and correct New Attempt Form via email or Canvas message to me no later than 24 hours in advance of your New Attempt.
  - You need a separate New Attempt Form for each question you are requesting.
  - If you cannot make scheduled Student Hours, you can request another time to be given a New Attempt outside of class at the Academic Proctoring Center.
- You are not limited in the number of New Attempts you request for the same objective.

Revision Form

Submit a separate form for each objective that you earned a "Needs Minor Revisions" mark. Be thoughtful and thorough in your responses; you will not get a second chance to revise an assessment problem.

Your name:	Date Submitted:
Circle one: In-class assessment or New Attempt	
Learning Objective/Problem #:	

1) Describe the mistake you made on your last assessment of this objective:

2) Correct your mistake below and explain how your understanding and process has been improved:

New Attempt Form

Submit a separate form for each objective that you earned a "New Attempt Required" mark. Be thoughtful and thorough in your responses; you will not be given a New Attempt at the requested date and time if the form in not well done.

Your name:	Date Submitted:
New Attempt requested for what date and time?	
Learning Objective/Problem #:	

1) Describe what errors you made in your last attempt of this objective:

2) Describe why you think you made these errors. Be honest.

3) Describe how your understanding of this objective has improved from the last attempt to show mastery.

4) On the back of this form, include a correct solution of the problem, and describe how you found this solution (e.g. got tutoring, talked to instructor, worked with classmate, etc).

Math 192 Demonstration of Mastery Checklist

Name ______________________________

Precalculus

P1. I can compute average rates of change and find slopes of secant lines. (2)		
P2. I can graph functions and identify main characteristics (domain, intercepts, asymptotes) with minimal technological assistance, given a formula. (2)		
P3. I can rewrite an absolute value as a piecewise function. (1)		
P4. I can evaluate trigonometric functions at known values.		

Limits

L1. I can graphically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation. (2)					
L2. I can algebraically evaluate the limit of any function at a point, or determine that it doesn't exist, using appropriate justification and notation. (5)					
L3. I can identify limits in indeterminate form and apply appropriate techniques to evaluate them. (5)					
L4. I can determine the points at which a function is (and is not) continuous, and can use continuity to evaluate limits. (2)					
L5. I can evaluate the limit of an expression "at" infinity and use these limits to determine asymptotes. (2)					

Differentiation Rules

D1. I can find the derivative of a function, both at a point and as a function, using the definition of the derivative, and I can identify the points for which a function is differentiable. (2)					
D2. I can use derivative notation correctly, state the units of a derivative, and correctly interpret the meaning of a derivative in context. (2)					
D3. I can find the equation of the tangent line to a function at a point. (3)					
D4. I can compute derivatives of polynomial, exponential, and logarithmic functions. (3)					
D5. I can compute derivatives using the product and quotient rules. (4)					
D6. I can compute derivatives of trigonometric and inverse trigonometric functions. (4)					
D7. I can compute derivatives of composite functions using the Chain Rule. (5)					
D8. I can compute the derivative of an implicitly defined function using implicit differentiation. (2)					

Applications of Differentiation

A1. I can sketch f, f', or f'' given a graph of f, f', or f''. (2)				
A2. I can use derivatives to solve problems in the natural and social sciences. (1)				
A3. I can use derivatives to solve problems involving related rates of change. (2)				
A4. I can find all critical points, local extrema, and inflection points of a given function. (4)				
A5. I can describe the relationship between the first derivative, second derivative, and the graph of a function and can use derivatives and limits to make informed sketches of the graph of a function. (2)				
A6. I can find the absolute extrema of a continuous function on a closed interval and use derivatives to solve optimization problems. (3)				

Integration

I1. I can find antiderivatives of standard functions and use indefinite integral notation to represent antiderivatives. (2)			
I2. I can use limits of Riemann sums to define the area under a graph and to calculate definite integrals. (1)			
I3. I can evaluate definite integrals using only simple geometric formulas. (1)			
I4. I can evaluate definite integrals using the Fundamental Theorem of Calculus. (1)			
I5. I can use definite integrals to measure change. (2)			
I6. I can evaluate integrals using the substitution method. (3)			

Math 192 Weekly Homework Report

Name: Section:

Week # Dates:

Lessons covered in class:

1. List the homework tasks that you worked on this week, including Derivita assignments, class handouts finished outside of class, or other tasks you initiated. Include how much time you spent on each task and how much of each task you completed.

Homework Task	Time Spent	How complete

2. Why did you choose to complete this level of homework this week? Do you feel like it was enough to solidify your understanding of the course objectives? Do you plan to continue to work on any of these assignments in the future?

3. Do you have any remaining questions about the problems that you worked on for homework this week? Use the back of the page to indicate any questions that you'd like help with.

Final Course Grade Requirements

The table below outlines the requirements necessary to earn each of the final course grades in this course:

A	• Earn credit for 14 Weekly Homework Reports • Achieve mastery on 25 of the course objectives
B	• Earn credit for 13 Weekly Homework Reports • Achieve mastery on 22 of the course objectives
C	• Earn credit for 11 Weekly Homework Reports • Achieve mastery on 20 of the course objectives
D	• Earn credit for 9 Weekly Homework Reports • Achieve mastery on 17 of the course objectives
F	Fail to meet the requirements of any of the above.

You will be provided with a tracking log you can use to record your mastery of objectives throughout the semester. You will also receive an email with an updated record of your progress toward mastery after each in-class assessment.

Sum of Mastery		Objective		
Last	**First**	**P1**	**P2**	**Grand Total**
Hendrix	Jim	2	1	3
Joplin	Janis	1	2	3
Keys	Alicia	1	1	2
Morrison	Jim	2	1	3
Santana	Carlos	2	2	4
Grand Total		**8**	**7**	**15**

Implementing Mastery-Based Grading in Math-192

What We’ll Talk About Today

- A summary of the drawbacks of the traditional point-based grading system
- A general framework of mastery-based grading systems
- A summary of benefits of a mastery-based grading system
- My materials for implementation in Math-192
- Resources

Drawbacks of the Traditional Points-Based Grading System

Incommensurability and Subjectivity of Grades

- Variability among instructors makes grades difficult to interpret (what is included, late penalties, extra credit, notes on exams, participation, etc)

The Course Becomes a Game: Maximize Points with Minimum Effort; Learning is Not the Central Theme

- Focus shifts to scores instead of learning; typical tactics for this include cheating, plagiarism, protesting scores, pressuring faculty

Does not Account for Learning over Time

- Prioritizes high-stakes assessments that create stress and anxiety, generally with no opportunity for students to demonstrate further mastery after the assessment date

Four Pillars of Mastery-Based Grading

- **Clearly Defined Standards**
  - Student work is evaluated through a set of clear and measurable actions that learners can take to demonstrate their learning, delineated from the beginning of the course.
- **Helpful Feedback**
  - Student work, when evaluated, is given helpful, actionable feedback that the student can and should use to learn and improve their work.
- **Marks that Indicate Progress**
  - Student work does not have to receive a mark, but if it does, the mark is a progress indicator and not an arbitrary number.
- **Reattempts without penalty (but not necessarily without limits)**
  - Students can revise, resubmit, and reattempt work without penalty, using the feedback they receive, until the standards are met or exceeded

(From: Grading for Growth blog, Finding Common Ground with Grading Systems)

Benefits of a Mastery-Based Grading System

- Allows students a more flexible timeline of learning
- Motivates students to master concepts rather than maximize points
- Respects the way that students actually learn
- Reduces stress around exams
- Improves teacher-student relations by eliminating arguments over points
- Cycle of feedback and improvement normalizes help-seeking behavior and metacognition
- Rewards students for following up on feedback and being productively persistent in working towards mastery
- Upholds high academic standards

Lindsey's Math 192 Mastery-Based System

- The course has 27 assessable objectives, based on the student learning outcomes of record (See *Math 192 Learning Outcomes Final*)
- Students will need to demonstrate mastery on each objective between 1 and 5 times, depending on the objective. An objective is "mastered" once the student demonstrates mastery the required number of times for that objective. Students will be given a form to track their own progress toward mastery. (see *Student Mastery Checklist*)
- The course is divided into 28 content lessons (see *Lesson List*). Each lesson has a Derivita assignment and an in-class worksheet associated with it (except Lesson 1).
- Students complete and turn in a weekly homework report (see *Weekly Homework Report*) asking them to record what tasks they have worked on in the week and to reflect on their level of understanding and possible future work on the associated course material.

Assessment and Reassessment Details

- Every 3 weeks there will be an in-class assessment covering the previous week's objectives. These in-class assessments will be the first opportunity for students to demonstrate all the instances of mastery required for the course.
- Students will be graded on the following scale: Successful, Needs Revision (requires a *Revision Form* within 3 days of receiving assessment feedback), New Attempt Required (requires a *Reattempt Form* 24 hours in advance of reattempt).
- A thorough and correct Revision Form will upgrade the attempt to Successful.
- Only Successful attempts count toward objective mastery.
- Students can reattempt a maximum of 2 problems per week, beginning in week 4. Reattempts are done in Student Hours or the Academic Proctoring Center.
- The final exam consists of 2 objectives not yet assessed and the last needed successful attempts for 11 other core objectives.

Final Course Grade Determination

A	• **Earn credit for 14 Weekly Homework Reports** • **Achieve mastery on 25 of the course objectives**
B	• Earn credit for 13 Weekly Homework Reports • Achieve mastery on 22 of the course objectives
C	• Earn credit for 11 Weekly Homework Reports • Achieve mastery on 20 of the course objectives
D	• Earn credit for 9 Weekly Homework Reports • Achieve mastery on 17 of the course objectives
F	Fail to meet the requirements of any of the above.

Keeping Track of Attempts and Successes

- I have followed the model provided by Tom Mahony to use pivot tables in Excel to track all student attempts, reattempts, and marks (Successful, Needs Revision, New Attempt Required) for all students.
- This record keeping provides a quick way to filter results per student, per problem, per outcome, etc.
- It also allows me to create a report for each student showing their progress toward mastery and email them to the students via a mail merge. I plan to mail them out after each in-class assessment is marked.
- You can find his videos on YouTube under Tom Mahony.

Resources for Further Exploration

- Specifications Grading, by Linda B. Nilson
- Ungrading, edited by Susan D. Blum
- Grading for Growth, (online blog) gradingforgrowth.com
- Grading for Equity, by Joe Feldman
- Shared alternative grading resources at https://drive.google.com/drive/folders/1GNSqfOb0LZS6BeAuc1tqPDZWKkPk11KT
- Tom Mahony YouTube Channel: https://www.youtube.com/@saxmahoney