

Creativity in Writing Calculus Exams

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Abstract

I will describe the different ways I incorporate creativity and art in the calculus exams I write, with specific examples. I incorporate creativity not only visually in the aesthetics of the exam layout, but also in the problems and theme of the exam.

Motivation for Writing Creative Calculus Exams

In my experience teaching, writing exams is one of my least favorite parts of teaching. I struggle with writing novel problems, as the implied expectation is that exams from semester to semester are different. As I mostly teach calculus courses with a common final exam, I have to collaborate with colleagues to write and edit the final exam, so I am exposed to the varying styles of my colleagues, which put a lot of pressure on me to create new and interesting problems. I have colleagues who are very creative in the style of problems they create, which encourages me to do the same.

To cope with my struggle in writing exams, I attempt to make it a fun exercise for myself by not only writing creative problems, but also having fun with the exam layout, style, and themes. I will outline the different ways that I do this.

Evolution of My Exam Style

The style of my exams has evolved a lot over the years. I initially wanted to fit in the mold of most other math instructors so I had exams that were indistinguishable from others. Plain white paper, cover page, straightforward math problems, and nothing else. In my first job as a Visiting Assistant Professor at Rose-Hulman Institute of Technology, I started experimenting with fonts and layouts. I thought that since exams and quizzes were stressful enough, maybe I should start making them look appealing. I started decorating the quizzes with drawings, changed the font on the title of each quiz, and even had a spot on the back of exams for students to leave comments.

Working at Rose-Hulman was such a big change for me in terms of access to resources. As a graduate student at UC Santa Cruz, due to it being a public university, I had to log how many copies I printed since printing was limited. Rose-Hulman was a private college with unlimited printing capabilities. It was wonderful, as they had a printing service where I would submit a form for what I need to be printed, and it would be delivered to my mailbox in the department the next morning. What I found amazing was that I also had a choice of using colored paper. I started to print my exams on colored paper because I thought it was fun and different. I would sometimes print the same exam on different colored paper to make it seem that there were two different exams. I recall printing an exam where each page was a different color, but this was something I had to put together and staple myself. My class materials were very distinct because my students would have documents colored by the rainbow. Later, after moving to USC, my exam style evolved beyond the surface of the exam font or color.

SCORE:

#	1	2	3	4	5	6	TOTAL
POINTS	/8	/5	/5	/6	/6	/15	/45

Figure 1: *A more typical scoring table with alternate font and design.*

1.	_____	/2
2.	_____	/2
3.	_____	/2
4.	_____	/4
5.	_____	/1
6.	_____	/23
7.	_____	/6
TOTAL:	_____	/40

(a)

1:	_____	/25
2:	_____	/15
3:	_____	/10
4:	_____	/20
5:	_____	/15
6:	_____	/15

(b)

1.	_____	(10)
2.	_____	(5)
3.	_____	(6)
4.	_____	(7)
5.	_____	(3)
6.	_____	(7)
TOTAL:	_____	(40)

(c)

Figure 2: Examples of tables for scoring exams: (a) a scoring table with the length of blank increasing, (b) a scoring table with the blank underscore line length corresponding to the value of the score, (c) an art nouveau styled scoring page with a vase-shaped scoring table.

Creativity in Exam Layout

I was getting bored with the typical LaTeX-style math exams that everyone else does. For example, white paper, a cover page with a place for a student’s name and ID, the label of the exam, and maybe a table with the problem numbers in front of point values to total the page. I stopped using a LaTeX editor to write my exams, but started using Microsoft Word due to the flexibility and ease in the layout and adding images. I understand that LaTeX is the best way to create nicely formed mathematical expressions, but I found the format to be too restrictive for me. For example, I don’t like the default fonts. I started using Garamond almost exclusively for all the course materials that I provide for my students. I am very picky about fonts, especially if it is something I am going to have to stare at for hours, and I like the shape and style of Garamond. It’s more delicate than Times New Roman and has a better, less harsh shape in my opinion.

I thought that if I am going to be wasting ink and paper, I might as well have fun with the design of the exam layout. Instead of having a table with the problem number and point value to total the points such as in Figure 1, albeit with alternative fonts, I had fun with it by making shapes with the tally list, as in Figure 2.

Exam 1, Math 118, Version 1
September 28, 2017, Instructor: Felicia Tabing

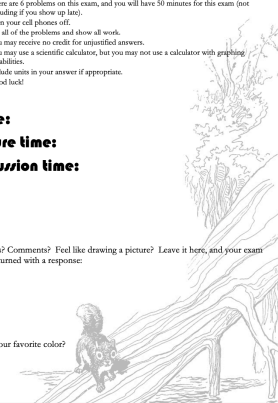
Instructions:

- You may start as soon as you receive the exam.
- Please write your name only on this page.
- There are 6 problems on this exam, and you will have 50 minutes for this exam (not including if you show up late).
- Turn your cell phones off.
- Try all of the problems and show all work.
- You may receive no credit for unjustified answers.
- You may use a scientific calculator, but you may not use a calculator with graphing capabilities.
- Include units in your answer if appropriate.
- Good luck!

Name: _____
Lecture time: _____
Discussion time: _____
TA: _____

Questions? Comments? Feel like drawing a picture? Leave it here, and your exam will be returned with a response:

What is your favorite color?



(a)

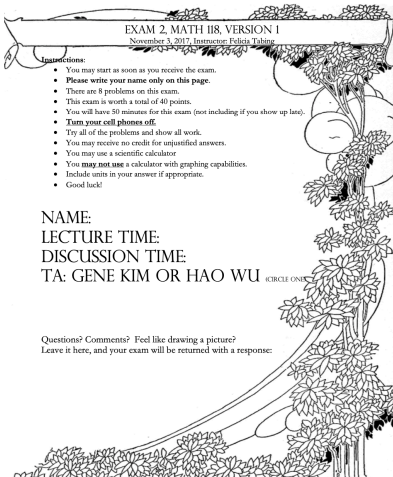
EXAM 2, MATH 118, VERSION 1
November 3, 2017, Instructor: Felicia Tabing

Instructions:

- You may start as soon as you receive the exam.
- Please write your name only on this page.
- There are 8 problems on this exam.
- This exam is worth a total of 80 points.
- You will have 50 minutes for this exam (not including if you show up late).
- Turn your cell phones off.
- Try all of the problems and show all work.
- You may receive no credit for unjustified answers.
- You may use a scientific calculator.
- You may not use a calculator with graphing capabilities.
- Include units in your answer if appropriate.
- Good luck!

NAME: _____
LECTURE TIME: _____
DISCUSSION TIME: _____
TA: GENE KIM OR HAO WU (CIRCLE ONE)

Questions? Comments? Feel like drawing a picture? Leave it here, and your exam will be returned with a response:



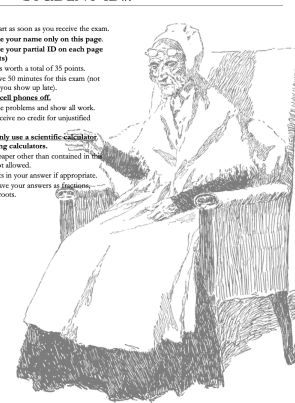
(b)

EXAM 2, MATH 118, VERSION 1
Friday, March 30, 2018, Instructor: Felicia Tabing

NAME: _____
STUDENT ID#: _____

Instructions:

- You may start as soon as you receive the exam.
- Please write your name only on this page.
- Please write your partial ID on each page (last 4 digits).
- This exam is worth a total of 35 points.
- You will have 50 minutes for this exam (not including if you show up late).
- Turn your cell phones off.
- Try all of the problems and show all work.
- You may receive no credit for unjustified answers.
- You may only use a scientific calculator.
- No graphing calculators.
- Notes and paper other than those in your exam are not allowed.
- Include units in your answer if appropriate.
- You may leave your answers as fractions, powers, or roots.
- Good luck!



(c)

Figure 3: Examples of the back page of exams: (a) back page with comment area and squirrel border (b) another example of the back page layout, (c) Grandma-themed cover page.

Another layout change I made was rather than having the cover page on the front of the exam, I placed it on the back, as can be seen in Figure 3. This was mainly functional to serve two purposes: one was so that I can tell that the students had the exam turned over before starting it, allowing me to hand out the exams early so that all students can start at the same time, and the other purpose was so when I handed the exams back, the scoring page will be the penultimate page, so the back would hide the student score so I can hand back their exams discreetly. I would also incorporate images and clipart on the back page to make it quick for me to see that students had the exam closed on the back page, and at the same time disguising any problems that they might be able to see through the page. I frequently sourced images from the University of South Florida's ClipArtETC which has a lot of historical, educational, and interesting clipart for educational use [1].

Design for Cheating Detection

During the pandemic, I had to create exams that students could download to take the exam. Something that occurred during the pandemic was an increase in cheating that was detectable. For example, other faculty members found that students were collaborating, and posting the problems to Chegg with paid access for others to solve the problems for them. The thing was, when some students posted problems to Chegg, the answers they received were not guaranteed to be correct, and often had strange errors. Another faculty member had a Chegg account that he ended up sharing with the rest of us to find students who were using Chegg, and the answers, as they were posted publicly. For one final exam, I was charged with finding the solutions and printing the PDF files to create evidence against students for cheating. Something I noticed is that some students just took a screenshot of their problem and posted it to Chegg. This encouraged me to make sure that my exams were immediately recognizable. I did this in several ways. I use Garamond, which is not a font that I notice my colleagues use. For exams that did not have distinct figures or images where I can identify my problems, I used watermarks on each page to identify the exam, along with the version or class, as seen in Figure 4. I doubt this has helped curb cheating, and students are not told the reason for the watermarks, but I think it gives my exams a certain look and feel.

5. Consider the following integral function:

$$F(x) = \int_{\frac{1}{4}}^{\cos^2(x)} \sqrt{1-t} dt$$

a. (2 points) Find $F\left(\frac{\pi}{3}\right)$

b. (5 points) Find $F'(x)$.

c. (4 points) Find the equation of the tangent line to $F(x)$ at $x = \frac{\pi}{3}$.

d. (3 points) Use the linearization you found in c. to estimate $\int_{\frac{1}{4}}^{\cos^2(1)} \sqrt{1-t} dt$. Give the exact answer, and you may leave it unsimplified.

4. Grandma is running out of money in her retirement account, so she is selling her vintage Hermes scarves and Chanel handbags to fund the rest of her retirement. If the price of her vintage Hermes scarves go for $\$H$, and the price of her Chanel handbags go for $\$C$, then the demand for her vintage items are

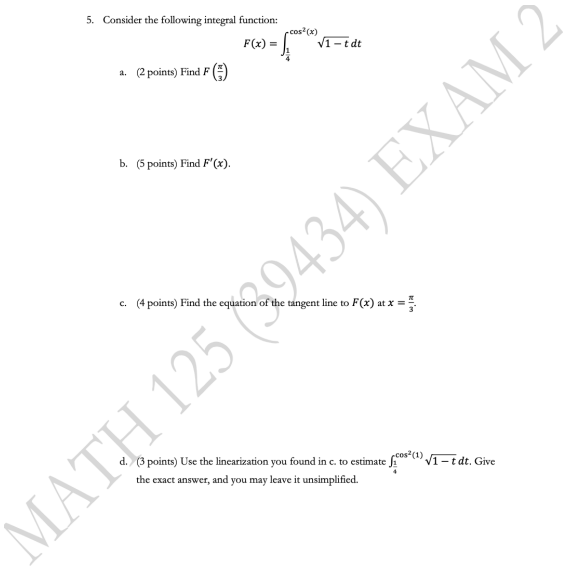


$$q_H = 4800 - 4H - C$$

$$q_C = 3000 - H - C$$

where q_H is the demand for the Hermes scarves, and q_C is the demand for the Chanel handbags.

a. (2 points) What does the fact that the coefficients of H and C are negative tell you about the demand for vintage Hermes scarves and Chanel handbags?

b. (2 points) Grandma received all of her Hermes scarves and Chanel handbags as a gift from a generous suitor long ago, so Grandma is not responsible for any of the costs of the items. This means that the profit she makes in selling her vintage goods is equal to her revenue. Write down Grandma's revenue equation for selling her Hermes scarves and Chanel handbags in terms of only H and C .

Math 125 Spring 2021 Exam 2 (39434) Instructor: Felicia Tabing, April 2, 2021

(a) (b)

Figure 4: (a) An example of a page from a calculus exam with watermarks to identify the exam, (b) Grandma-themed exam problem about funding her retirement.

Exam Themes and Humor

The best way that makes exam writing less painful for me is not just by making it visually appealing, but by having fun with the theme of the exam. One Spring semester, I had an idea to create a Valentine’s Day-themed exam, with problems featuring revenue from selling roses or tracking the rate of change of the price of chocolates. A Fall semester exam was Halloween and pumpkin-themed, with a problem I was particularly proud of that featured the growth rate of a pumpkin for which students had to answer questions about the pumpkin’s weight and another problem where students had to give an estimate to replace the cost of a window that was shattered due to trick-or-treaters having hurled their bucket at it.

I also created themed exams that were based on my hobbies. For example, one exam was plant themed, due to my love of gardening, and featured a problem on exponential decay based on a quote by Theodore Payne, a historical figure and California horticulturist, on the pricing model of apple trees (Figure 5(b)). Another exam was themed on a grandma, where in one problem students are given grandma’s velocity throughout a 40-minute drive, and they have to figure out whether or not she successfully made the distance to visit her grandchild at USC from her home (she doesn’t make it). Another problem has grandma selling her luxury goods to fund her retirement (Figure 4(b)). There is also a problem that features a graph with the rate of change of her height throughout her life, and of course, the rate of change decreases at a certain age, and students have to figure out her height (Figure 5(a)). It has been very entertaining for me to make themed exams and pull problems inspired by life.

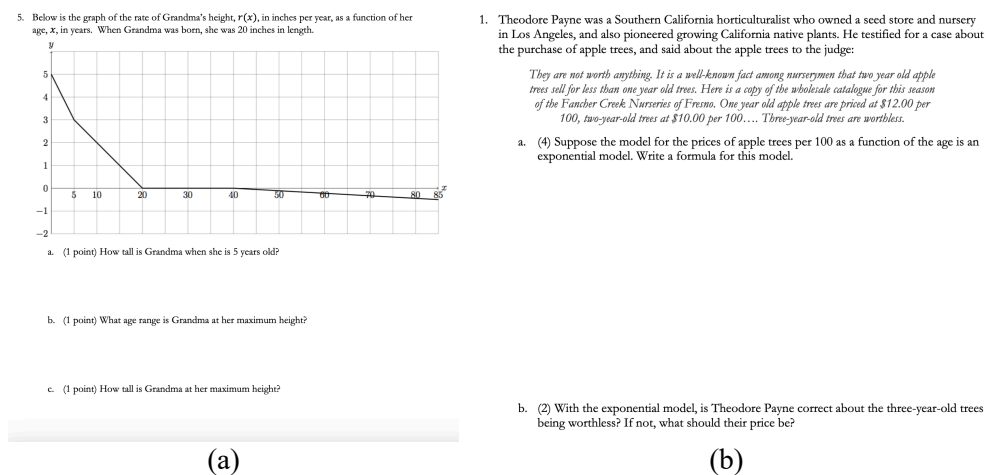


Figure 5: (a) Grandma-themed exam problem, (b) gardening-themed exam problem..

Outcomes

Although these described efforts in creating exams often go unmentioned and unnoticed by students, I think it is still worthwhile. It is questionable whether or not this affects my students’ experience of taking a mathematics exam, or the pedagogical merits, but I do believe it has an impact in breaking down the distance between myself and my students, and sparking informal conversations between us. Just this semester, since a quiz was due on Valentine’s day, I put red hearts next to the due date. One student told me she thought it was cute and made it less stressful by seeing the hearts. The grandma-themed driving problem started a conversation in a class about students’ grandmothers, allowing me to get to know more about them personally. Among my colleagues, I am known for writing creative final exam problems that use real-life situations and using real data, as I frequently pull inspiration from my life. Colleagues and students enjoying my efforts is enough motivation for me to continue with being creative in making my calculus exams.

References

[1] University of South Florida ClipArtETC. <https://etc.usf.edu/clipart/>