

Scanning tests on colored paper for Gradescope, and other Gradescope issues  
 Glenn Tesler, April 17, 2018

Swatches of scans in each paper color (shrunk to fit on one page)

Color scan		Grayscale scan	
Front	Back	Front	Back
 <p>white Midterm 2 (v. D) (Total Points: 39)</p>	 <p>white <math>5xy - 5y + 500.</math> tangent plane to the surface</p>	 <p>white Midterm 2 (v. D) (Total Points: 39)</p>	 <p>white <math>xy - 5y + 500.</math> tangent plane to the surface</p>
 <p>Canary Midterm 2 (v. C) (Total Points: 39)</p>	 <p>Canary <math>xy - 5y + 400.</math> tangent plane to the surface</p>	 <p>Canary Midterm 2 (v. C) (Total Points: 39)</p>	 <p>Canary <math>xy - 5y + 400.</math> tangent plane to the surface</p>
 <p>Blue Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Blue <math>5xy - 5y + 200.</math> tangent plane to the surface</p>	 <p>Blue Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Blue <math>xy - 5y + 200.</math> tangent plane to the surface</p>
 <p>Green Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Green <math>xy - 5y + 200.</math> tangent plane to the surface</p>	 <p>Green Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Green <math>xy - 5y + 200.</math> tangent plane to the surface</p>
 <p>Pink Midterm 2 (v. D) (Total Points: 39)</p>	 <p>Pink <math>xy - 5y + 500.</math> tangent plane to the surface</p>	 <p>Pink Midterm 2 (v. D) (Total Points: 39)</p>	 <p>Pink <math>xy - 5y + 500.</math> tangent plane to the surface</p>
 <p>tan Midterm 2 (v. C) (Total Points: 39)</p>	 <p>tan <math>xy - 5y + 400.</math> tangent plane to the surface</p>	 <p>tan Midterm 2 (v. C) (Total Points: 39)</p>	 <p>tan <math>xy - 5y + 400.</math> tangent plane to the surface</p>
 <p>Gray Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Gray <math>5xy - 5y + 200.</math> tangent plane to the surface</p>	 <p>Gray Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Gray <math>xy - 5y + 200.</math> tangent plane to the surface</p>
 <p>Buff Midterm 2 (v. B) (Total Points: 39)</p>	 <p>Buff <math>xy - 5y + 300.</math> tangent plane to the surface</p>	 <p>Buff Midterm 2 (v. B) (Total Points: 39)</p>	 <p>Buff <math>xy - 5y + 300.</math> tangent plane to the surface</p>
 <p>Lavender Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Lavender <math>5xy - 5y + 200.</math> tangent plane to the surface</p>	 <p>Lavender Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Lavender <math>xy - 5y + 200.</math> tangent plane to the surface</p>

Swatches provided for reference,  
 but colors aren't recommended:

 <p>Ivory Midterm 2 (v. B) (Total Points: 39)</p>	 <p>Ivory <math>xy - 5y + 300.</math> tangent plane to the surface</p>	 <p>Ivory Midterm 2 (v. B) (Total Points: 39)</p>	 <p>Ivory <math>xy - 5y + 300.</math> tangent plane to the surface</p>
 <p>Goldenrod Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Goldenrod <math>5xy - 5y + 200.</math> tangent plane to the surface</p>	 <p>Goldenrod Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Goldenrod <math>xy - 5y + 200.</math> tangent plane to the surface</p>
 <p>Salmon Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Salmon <math>5xy - 5y + 200.</math> tangent plane to the surface</p>	 <p>Salmon Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Salmon <math>xy - 5y + 200.</math> tangent plane to the surface</p>
 <p>Cherry Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Cherry <math>5xy - 5y + 200.</math> tangent plane to the surface</p>	 <p>Cherry Midterm 2 (v. A) (Total Points: 39)</p>	 <p>Cherry <math>xy - 5y + 200.</math> tangent plane to the surface</p>

## Recommended paper colors

I experimented with settings on our “**HP Digital Sender Flow 8500 fn1 Document Capture Workstation.**” The scanner instructions by John Eggers and Marc Loschen work well for white paper, but I found that other settings work better for colored paper. I tried a variety of Image Adjustment and Color Dropout settings.

As of Winter 2018, UCSD Imprints has 13 available paper colors for 20 lb 8.5”x11” paper. I tried samples of them all with a variety of scanner settings, and used 10 of the 13 paper colors on actual exams.

### Recommended paper colors and color combinations for multiple versions:

- **1 color:** White. Most exams are ordered on white paper.
- **2 colors:** White and Canary (light yellow) are cleanest.
- **4 colors:** Blue, Green, Canary, Pink (or substitute Blue, Green, or Pink by White).
  - These are the most popular colors ordered for exams on colored paper.
  - I usually have alternating rows, with one row alternating blue/green and the next yellow/pink.
- **6 colors:** White, Blue, Green, Canary, Pink, Tan
- **If you need additional colors:** Gray, Buff, Lavender. However:
  - Gray apparently can be mistaken for white when students turn in exams by color.
  - Buff is an off-yellow, close to canary, and canary gives cleaner scans.
  - Lavender is darker than the rest; it’s legible but on the cusp of what’s useable.
- **Email vs. USB:** Either is acceptable for white paper. For all other colors, a high-capacity USB 2.0 or 3.0 stick is generally better, to avoid splitting scans into multiple files; see later in this report.

### Avoid:

- Ivory: I used it on exams and there were problems. Avoid it. See below.
- Goldenrod is another off-yellow, much darker than canary and buff. It scans legibly and it potentially could work if you really need an additional color, but canary is much cleaner.
- Salmon, Cherry: Too dark.
- I only used Goldenrod, Salmon, and Cherry in scanner testing, not in exams given to students.

Ivory is an off-white that looks fine by eye but scans poorly, since the paper is translucent.

Scanning Ivory colored paper Image Adjustment settings Color, 2-sided				Grayscale, 2-sided		Color or grayscale, 1-sided	
Darkness	+3	Contrast	-4	+4	-4	+4	0
Background	0	Sharpness	+2	0	+2	0	+2

- To get both the front and back sides to scan legibly in color, I used the color 2-sided settings above. It’s legible enough to grade, but the back side of the paper bleeds through on scans of the front-sides (see swatches). Gradescope’s automatic name recognition failed on all tests scanned with these settings.
- For grayscale, the grayscale 2-sided settings above pick up both front and back sides, but it looks terrible.
- The 1-sided settings above give good scans on the front sides, and Gradescope’s automatic name recognition works. However, the back-side scans are too light, so these are unsuitable for 2-sided scans.
- For good scans of ivory, one could scan the front and back sides separately (by flipping the stack) using the 1-sided settings shown above, and then interlace the scans. However, there are plenty of colors w/o these issues, so just don’t use ivory.

### Other issues:

- Color Dropout does help remove some background colors, but the Image Adjustment settings were sufficient. “Red” dropout also removes red pens, but “blue” dropout did not remove the blue pen I used.
- The next page lists settings for 2-sided scanning. The backside scans are generally lighter and noisier than the fronts. There may be better settings for 1-sided only scanning, as described above for ivory.

**HP Scanner Settings with white or colored paper**  
**Glenn Tesler, April 2018 (Updating the instructions from John Eggers and Mark Loschen)**  
**For more info: <http://math.ucsd.edu/~gptesler> under "Instructor Resources"**

1. Sort exams by version and color. Sort each stack alphabetically (to facilitate fixing any scanning/uploading problems later). Separate out any exams with extra pages and scan them individually.
2. Cut off the stapled corners from each exam. Scissors work much better than the guillotine cutter.
3. Scan the exams using an HP scanner in the department printer rooms. The scanner can hold batches of ~100 sheets, comprised of multiple students' exams; however, if you use the email option, you may need to use smaller batches (~45 double-sided white sheets, or ~10-20 double-sided color sheets, depending on color) to avoid splitting the file in the middle of an exam. If batches are split into multiple files, you may need to combine them in Adobe Acrobat Pro or other software before uploading to Gradescope.
4. Here are the steps on the HP scanners:
  - a. Press [Email] or [USB].  
For Email, fill in the address for To:, and optionally fill in other fields.
  - b. Press [File Name] and enter the filename. E.g., "mt2-yellow1", "mt2-yellow2", ... The scanner adds a timestamp to the filename; if that's enough for you, you don't necessarily have to change the filename for each batch.
  - c. Press "More options" to get to the 2<sup>nd</sup> page of options. Use arrows to get back.
  - d. Select "Original Sides" and set it to 2-sided.
  - e. Select "Color/Black" and set it to "Color" for color scans, or "Black/Gray" for grayscale.
  - f. Select "Image Adjustment" and set the sliders according to the paper color.  
 "0" = default, "+x" = x notches to the right, "-x" = x notches to the left.  
 Darkness +4 and Sharpness +2 are all the way right.  
 Contrast -4 is all the way left.

Scanning in color				Yellow, Green, Buff, Tan, Gray		Blue, Lavender		Pink	
Paper color: White									
<b>Darkness</b>	+4	<b>Contrast</b>	-4	+4	0	+3	0	+4	0
<b>Background</b>	0	<b>Sharpness</b>	+2	0	+2	0	+2	+1	+2

Scanning in grayscale				Yellow		Pink, Green, Buff, Tan, Blue, Gray, Lavender	
Paper color: White							
<b>Darkness</b>	+4	<b>Contrast</b>	-4	+4	0	+4	0
<b>Background</b>	0	<b>Sharpness</b>	+2	0	+2	+1	+2

- g. Load a batch into the tray, face up with the clipped corner towards the feeder.
  - h. Press [Send Email] or [Save to USB] to start the scan.
  - i. Check the box to "Retain settings for next job" and press [OK].
  - j. Repeat (b-i) until all exams are scanned. Any of steps (b-f) can be skipped if the retained settings are suitable, but you may need to change them when changing colors.
5. Scan exams with extra pages separately. Try the settings for the main color on the whole test. If the extra pages don't scan well, then scan them separately according to their paper color and combine the files.

### Order to upload exams

- If you used email and it split a batch into two or more files, use Adobe Acrobat or other software to merge the fragments of the batch into one file before uploading (rather than uploading the separate fragments).
- In Gradescope, select the assignment (exam) and follow the instructions under Manage Scans
- Gradescope presents exams in the order the scan files are uploaded. To facilitate grading multiple versions as one Gradescope assignment, upload all of one version, then all of the next version, etc. If a version is printed in multiple colors, then upload by color within each version. Graders should be alert to when the version changes.
- Gradescope allows you to start uploading one file while it's still uploading the previous file. However, the 2<sup>nd</sup> file may complete uploading before the 1<sup>st</sup>, which will disrupt the intended version/color order. So, upload one file at a time if version/color order is important.
- If any student's test will not be available until after the rest of the class has been uploaded, you may want to give them the "last" version/color of the exam, since uploading their exam late will put it last in the grading order. This might apply to students with extended time (completed after the regular exam) and students taking the test late, provided that they are still taking one of the regular test versions.

## Scanning to Email vs. USB Drive

Scanned files can be saved either to a USB stick or sent by email. Pick your poison; they both have pros and cons. The scanner also can save to a Network Folder and to SharePoint, but these features are not set up, possibly due to storage space requirements (potentially 10s-100s of GB added per day during exam periods).

For scanning **white paper only** in stacks of ~90 pages (45 double-sided sheets), in color or grayscale:

- After scanning, it takes a while to process the file. With email, you can leave the scanner and wait for the email to arrive. With a USB drive, you have to wait till it finishes before you can remove the USB drive and leave.

**Winner: Email (arguably), but USB stick is acceptable**

For scanning larger stacks or scanning colored paper, whether color or grayscale... short version:

- **Winner: USB stick. Email is way more tedious.**
- A USB stick saves the whole batch as a single file, no matter how large, while email may split the batch into multiple files, which messes up Gradescope and requires additional work after scanning.
- Use a recent, fast, high-capacity USB 2.0 or 3.0 stick, with FAT formatting. My decade-old USB 1.0 stick was painfully slow, while a USB 3.0 stick takes about the same scanner processing time as email.

Long version:

- When scanning to email, the scanner splits the output into multiple PDF files, approx. ~18-19 MB each. This expands ~40% to ~26-27 MB in base64 encoding for an email attachment. A batch of 66 double-sided blue sheets (132 pages total) scanned in color yielded 1 file on a USB stick vs. 7 files by email.
- The split may be in the middle of an exam booklet, which is problematic in Gradescope. Each part of a split job is received as a separate email. You have to wait for multiple emails to arrive several minutes apart; separately save attachments from each; and use Adobe Acrobat Pro or other software (like LaTeX's pdftpages package) to combine them into a single PDF. Repeat for each batch. This is tedious and way more inconvenient than waiting for it to save to a USB stick as one file.
- The number of pages per file varies with paper color, scanner settings, and the page contents. For colored paper scanned in color, I found roughly 20-40 pages (meaning 10-20 double-sided sheets) fit one email attachment, depending on the color, so this is less practical than with white paper. See file size plots at the end of this report.
- Sending scans by email may fill your email box.
  - For a final exam with 184 students, 10 pages/each (5 double-sided sheets), in 8 colors, I scanned 19 batches (2 large batches for each color, plus 3 tests scanned individually.)
  - **USB stick:** 19 PDF files comprising 1483 MB.
  - **Email attachments (estimated):** ~89 PDFs sent as separate emails, comprising ~2 GB in email attachment format.
  - White paper or fewer colors would have reduced the number of batches and files, but the point remains, it has the potential to fill your mail box.
- Saving to USB is easier, but you do have to wait at the scanner for it to finish writing to the USB drive. Delays ranged from a few minutes for short jobs scanned alone, to ~38 minutes for the final exam described above (scanning multiple batches consecutively and waiting afterwards for all of them to finish writing to USB, instead of waiting for each batch individually). Other people can use the scanner while you're waiting if they are sending it to email, though their emails will be similarly delayed.

## Gradescope rosters

This may change if Gradescope is integrated with TritonEd in the future.

**Creating a Gradescope roster:** make a file in .csv format with the following fields, in any order (the order on TritonLink/TritonEd is shown); see the next page for tips on making this in EXCEL:

SID, LastName, FirstName, Username, Email  
or SID, Name, Username, Email

- **SID:** Student ID (our PID).
- **Username:** TritonEd username; this is not a standard Gradescope field.
- **Email:** @ucsd.edu email address.
- Gradescope uses the email address to identify student accounts, and uses the name and SID fields to match the handwritten name/Student ID to its roster.  
TritonEd uses Username to match uploaded scores to its roster.

### Uploading roster to Gradescope:

- Select whether there is a single name column, or separate first and last name columns.
- Gradescope proposes how to match your columns to its standard columns (SID, LastName, FirstName (or just one Name), Email). Adjust this if needed.
- TritonEd needs Username, but this isn't a standard Gradescope field, so Gradescope will initially ignore it. Use ⊕ (circled plus) to add a new field. Pick the Username column in your roster and fill in "Username" in the description.
  - If you don't do this step, Gradescope will discard the "Username" column.
  - If you skipped this step when you initially uploaded the roster, you can upload an updated roster with this column.
- If you're just using Gradescope for exams uploaded by the instructor/TAs, you don't need to notify students about their accounts when uploading the roster; instead, notify them when their first graded exam is "published." But if students will upload assignments, you may want to notify them at this stage.

**Downloading grades from Gradescope and uploading to TritonEd:** For ID purposes, the score file includes Gradescope's standard columns and any additional columns you uploaded (in this case, "Username"). It also includes the score columns and other data. Upload the Username and appropriate score column(s) to TritonEd.

**Accounts for TAs, additional instructors, Concurrent Enrollment, test accounts,....:** Manually enter these as single users *after* uploading the roster, since field customizations can only be set by uploading rosters. If you manually enter your TAs first by full name, and then upload a roster with separate last, first columns, it will convert the roster to full name format and won't let you change views from full name to last, first. Gradescope's tech support confirms this behavior, but they were able to switch my class back to separate last & first columns.

**Adds:** I waited until the first midterm to upload the roster, so there were no further adds. However, if you use Gradescope with homework assignments or quizzes earlier in the quarter while students are still adding, you'll need to go back in and add the late-adds. For Gradescope and all the online homework systems, I prefer to add the new students to the system myself so that the name, username, email, etc. is 100% consistent between all systems (to facilitate syncing with TritonEd, etc.). Some faculty prefer to let students self-enroll, either from the beginning or at least the ones who add late; while this may save you time up-front, you may spend extra time later dealing with inconsistencies that impede exporting grades to TritonEd or a spreadsheet.

**Drops:** I did not drop students from Gradescope who dropped in the middle of the term. Students only can access assignments they submitted. Assignment statistics, emails about an assignment within Gradescope, etc., only include students who submitted the assignment. However, after uploading an assignment and matching names, it will tell you there are still x students not matched, and if there were any glitches, you may have to figure out whose assignments need to be re-uploaded. With just two exams in one class and three in another, it was easy enough to check which students had dropped and which ones needed to be re-uploaded. But with weekly

assignments or a large number of people dropping, this might become cumbersome. However, if you do drop them, you will lose all their submissions and scores, which could be problematic if you need to refer to them in the future (if they re-add, or if there is an administrative issue). By contrast, in WebAssign (for weekly online homework), the extra names did cause me a bit of extra work, but WebAssign has provision to move people to a “Dropped” list that keeps their scores and work in the system but separates them from the enrolled students.

### Using EXCEL to make a Gradescope Roster

TritonLink & TritonEd roster formats have either Username or Email but not both. I made a script to convert to Gradescope’s format, but you can do it in EXCEL as follows.

- Use the formulas below, adjusting row/column references D2, D3, etc. as needed.
- Copy it down the column to all other rows.
- If you include TAs, additional instructors, Concurrent Enrollment, or test accounts in the roster, the formulas below might not apply to them. Enter those rows manually, overriding the formulas, or just enter them within Gradescope as single users **after uploading the spreadsheet with the regular students.**

**If the Username column is filled in, then generate the Email column with this formula:**

	A	B	C	D	E
1	SID	LastName	FirstName	Username	Email
2	A12345678	Smith	Alice	asmith	=CONCATENATE(D2, "@ucsd.edu")
3	A23456789	Smith	Bob	bsmith	=CONCATENATE(D3, "@ucsd.edu")

**If the Email column is filled in, then generate the Username column from it with this formula:**

	A	B	C	D	E
1	SID	LastName	FirstName	Username	Email
2	A12345678	Smith	Alice	=SUBSTITUTE(E2,"@ucsd.edu","")	asmith@ucsd.edu
3	A23456789	Smith	Bob	=SUBSTITUTE(E3,"@ucsd.edu","")	bsmith@ucsd.edu

## Instructions for students, and exams with extra sheets

### Included in my exam announcement in advance:

We will be scanning the tests. Please use only black pencils (#2 pencil or darker; HB or B lead for a mechanical pencil). Black or blue ballpoint pens are also OK. Do not use pens that bleed through the paper. Please don't write near the edge of the paper or the stapled corner.

Jelena Bradic found that “H” mechanical pencil leads are common but don’t scan well (despite being readable by eye). I found that writing within ~3mm (1/8”) of the edges may be missed. Another solution besides warning not to write near the edges would be to provide answer boxes or lines on the exam.

### Included in the instructions on the exam:

Write your solutions clearly and legibly in the space provided. If you need more space to finish a problem, ask a proctor for paper (do not use your own paper or blue book). However, scratch paper is not allowed.

**Students who need extra paper:** Leave enough space to answer the questions, but some students may need more space anyway. I don’t allow scratch paper, but if a student requests more paper to finish a problem, I’ll provide a “Continuation sheet” with this at the top. I printed continuation sheets on white paper instead of each test color.

**Name:** \_\_\_\_\_ **PID:** \_\_\_\_\_ **Problem #:** \_\_\_\_\_

- Write “continued on extra sheet” on the page where you ran out of space.
- Fill in the info above and continue your answer below.
- Staple this continuation sheet to the end of your exam booklet.

**Scanning a test with extra sheets:** Separate exams with extra sheets and scan those exams individually, as they require additional steps to upload to Gradescope. If the test booklet and continuation sheets are different colors (e.g., booklet is on colored paper and continuation sheet is on white paper), then scan with the settings for the main color and check whether the continuation sheets scanned legibly. If not, you may need to separately scan the test booklet and continuation sheets with appropriate settings for each and combine the two files. The handful of continuation sheets I’ve scanned so far worked fine under the colored paper settings.

**Uploading a test with extra sheets:** If an exam is more pages than the template, Gradescope will initially split it into 2+ proposed exams, with the last one possibly having a warning due to too few pages. Starting with the last exam fragment, use the option to merge it with the previous one, working backwards till that submission is intact.



## Gradescope Rubrics

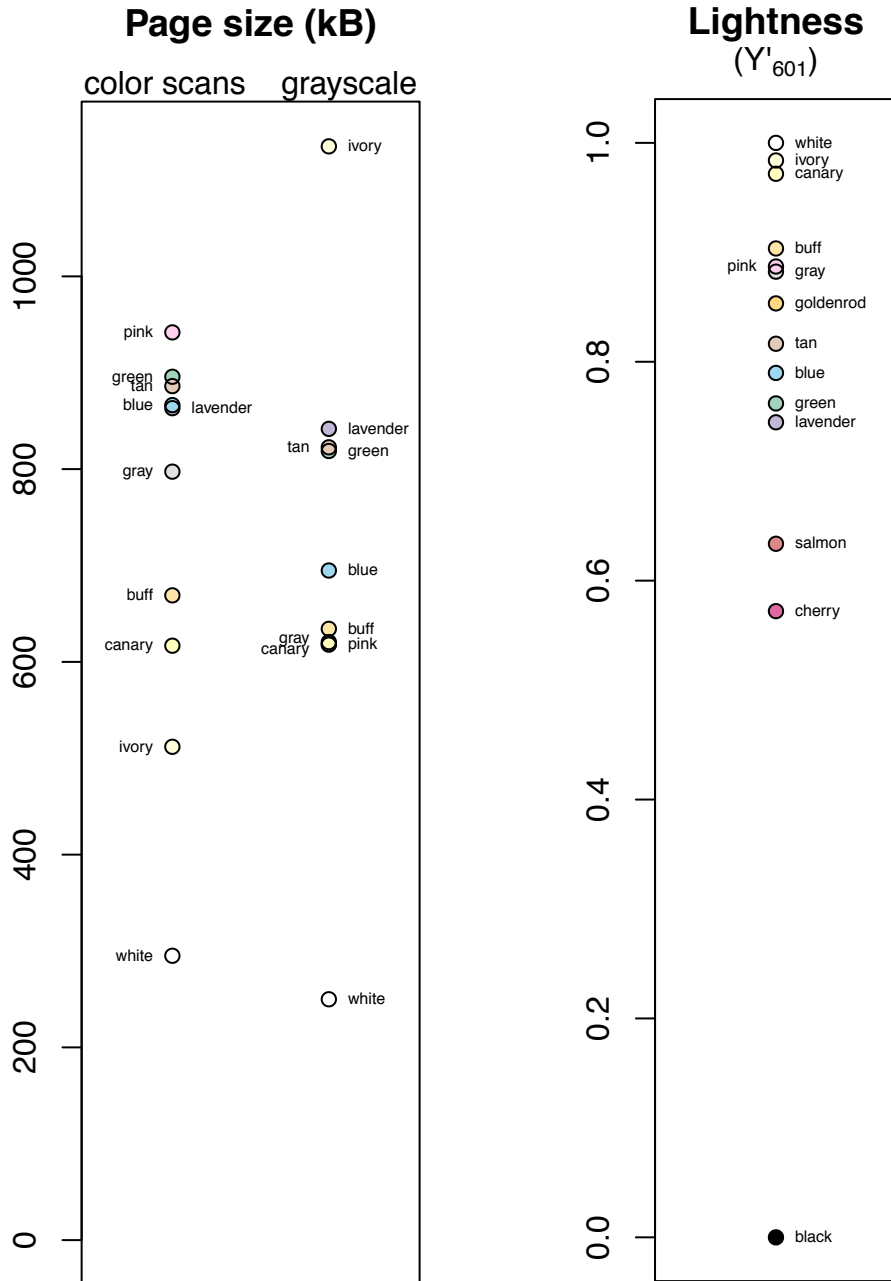
We should develop training materials on using Gradescope, including scanning, uploading, rubrics, etc. It should be available to all instructors and TAs in Math courses, including undergrad TAs and grad students from other departments, not just the Math Graduate Student TAs. These items about rubrics came up in my classes and in discussions with people using Gradescope in other classes. This is just a starting point and needs to be fleshed out.

- Making rubrics, partial credit, alternative solutions besides the intended method. While an instructor usually makes an answer key or starting rubric, some students will use other methods.
- One grader wanted all rubric items to add up to the points on the problem. But it's ok to have multiple solution methods, errors, etc. that overlap in point allocations, as long as they're applied carefully.
- Point adjustments and comments were sometimes used when rubric items would have been better. Currently it's hard to find these in Gradescope. I wrote a script to scan the "Export Evaluations" files to flag problems/submissions with point adjustments or comments so I could review them, and I wrote to Gradescope to suggest listing them in a similar way to the rubric Statistics screen.
- Grading multiple parts (a),(b),... as separate problems vs. as one combined problem.
  - If they are separate problems on the Gradescope template, particularly if they span 2+ pages, it may be harder to deal with errors in one part that propagate into the next part. It's common to avoid double-penalizing when an error in (a) propagates to (b). E.g.,  
  
-0 with negative scoring, or +[full points on (b)] with positive scoring, for  
“(b) Correct solution method on erroneous numbers carried from (a).”  
  
if you grade it as one problem, you'll immediately know the error in (a) affects (b).  
But if you grade it as separate problems, you may have to look back at (a) when grading (b).
  - If (a),(b),... are combined on the Gradescope template, the min/max score per part will not be automatically enforced. E.g., suppose (a),(b) are each 5 points, and (a) is perfect but you mark off multiple items totaling 7 points off for (b). As separate problems, the score  $5-7=-2$  for (b) is capped between  $[0,5]$  and becomes 0, yielding a total  $(a)+(b)=5+0=5$ . But as a combined problem, the total is  $10-7=3$ , with the additional points deducted on (b) eating away at the points for (a).
  - If they're combined on the template, annotate the rubric items with “(a) ...”, “(b) ...” unless it really applies to the whole problem (like “Correct” or “Blank”).
- Positive vs. negative rubrics.
  - In principle, positive rubrics may be friendlier, and it may be easier to give partial credit in some cases, but the equivalent can be done with negative rubrics.
  - Gradescope has options to show students the full rubric, hide the rubric, or only show the rubric items that apply. For a problem with a negative rubric, all of these options are respected. For a problem with a positive rubric, it shows students all rubric items even if you select to only show the rubric items that apply. This may lead to confusion or regrade requests on items that don't actually apply to that individual's test. So, I currently prefer negative rubrics with the option selected to show only rubric items that apply.
  - For a page with a manually graded series of multiple choice problems, with, e.g., 1 point for each correct part, 0 for each incorrect part, is it better to use a positive rubric (select all correct parts) or negative rubric (select all incorrect parts)? We decided that if the average would likely be above 50%, then a negative rubric would be faster.
- Multiple exam versions:
  - If corresponding problems appear in the same place and one template is sufficient, then upload all versions as one assignment, and design the rubric to fit all exam versions.
  - However, if you use Gradescope's automatic grading of multiple choice, etc., this might not be feasible. But I have not yet used that feature and don't know for certain.
  - If you upload multiple versions as separate assignments, you need to manually keep the rubrics in sync. Edits in the rubric of one version will not automatically propagate to the other versions.

### Scan file sizes for different paper colors, and paper color lightness

**Left plot:** average file size per page on a sample of exams. File size will vary depending on the page contents, paper color, scanner settings, etc., and the sample sizes are small, so your results will vary. This is just intended to illustrate that the paper color affects the scan file size, and that while it's practical to scan large stacks of white paper to email without splitting the file, the page limit will be much smaller with colored paper.

**Right plot:** paper lightness ( $Y'_{601}$ ) on a scale 0 (darkest) to 1 (lightest). The lightest paper colors are white, ivory, canary (light yellow), and buff, but ivory did not scan well. Salmon and cherry are too dark.



### Scan size (kb) per page as front-side vs. back-side scans

In most colors, the quality of front-side scans is visually much better than back-side scans. I noticed that the file sizes for front and back sides are also different; for some paper colors, the fronts are larger than the backs due to capturing more detail, while for other colors, the backs are larger than the fronts due to increased noise. I scanned a pile of tests, flipped it, and scanned it in the other direction, so the same pages are scanned both as front-side and back-side scans. Most of these use four 10-page final exams in each color (page #s plotted as 1-9 and "a" for 10), except buff and ivory use six 6-page midterms. The 45° line is where the front and back sides have equal size.

