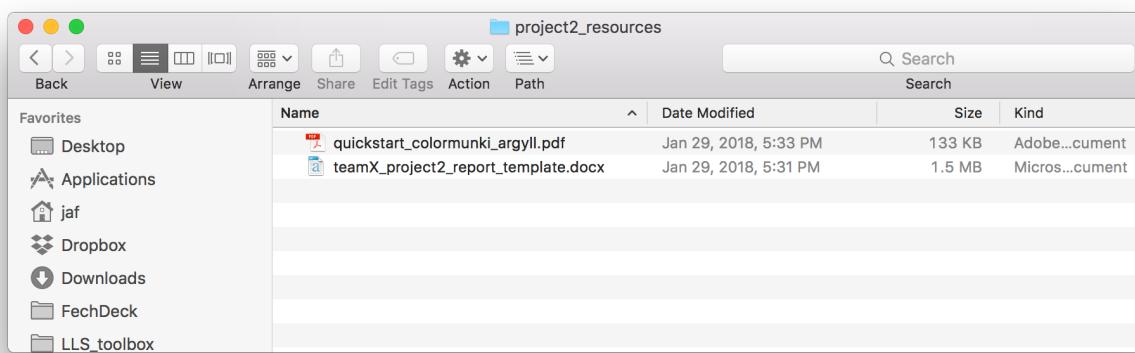


Project 2: Color measurement

In this project you will first install software on your computer to support the ColorMunki spectrophotometer. Next you will use the ColorMunki to measure the colorimetric (XYZ/Lab) values and reflectance spectra of the color patches you received in Project 1. You will then show the image of the patches you created in Project 1 on your laptop and measure its colorimetric values and reflectance spectra. Next you will create adjustable color patches on your laptop, make visual matches to the real patch colors, and measure them. Finally you will tabulate the colorimetric measurements, and plot the spectral curves of the real, imaged and matched patches.

- 1) a) Download and unpack the “project2_resources.zip” file provided on myCourses to your working directory. b) Follow the instructions in the document quickstart_colormunki_argyll.pdf to install the Argyll CMS software on your computer.



2) a) Follow the instructions below to use the ColorMunki with the Argyll "spotread" function to measure the colorimetric (XYZ, Lab) values and reflectance spectra of the real #.1 and #.2 color patches. (red text indicates required commands/inputs) b) Save this data! You will need it for later projects.

substitute your patch #

dharma.local% **spotread 31_XYZ_Labs_real.txt**

Spot read needs a calibration before continuing
Set instrument sensor to calibration position,
and then hit any key to continue,
or hit Esc or Q to abort:
...

Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take a reading:

Result is XYZ: 18.217468 18.388513 9.602670,
D50 Lab: 49.963981 2.581140 16.076209

Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take a reading: **s**

Enter filename (ie. xxxx.sp): **31.1_imaged.sp**

Writing file '31.1_imaged.sp' succeeded

Place instrument on spot to be measured,

...
Hit ESC or Q to exit, instrument switch or any other key to take a reading:

Result is XYZ: 8.690725 9.379692 4.309553, D50 Lab: 36.705288
-2.996538 16.104700

Place instrument on spot to be measured,

...
Hit ESC or Q to exit, instrument switch or any other key to take a reading: **s**

Enter filename (ie. xxxx.sp): **31.2_imaged.sp**

Writing file '31.2_imaged.sp' succeeded

Place instrument on spot to be measured,

...
Hit ESC or Q to exit, instrument switch or any other key to take a reading: **Q**

Spot read stopped at user request!

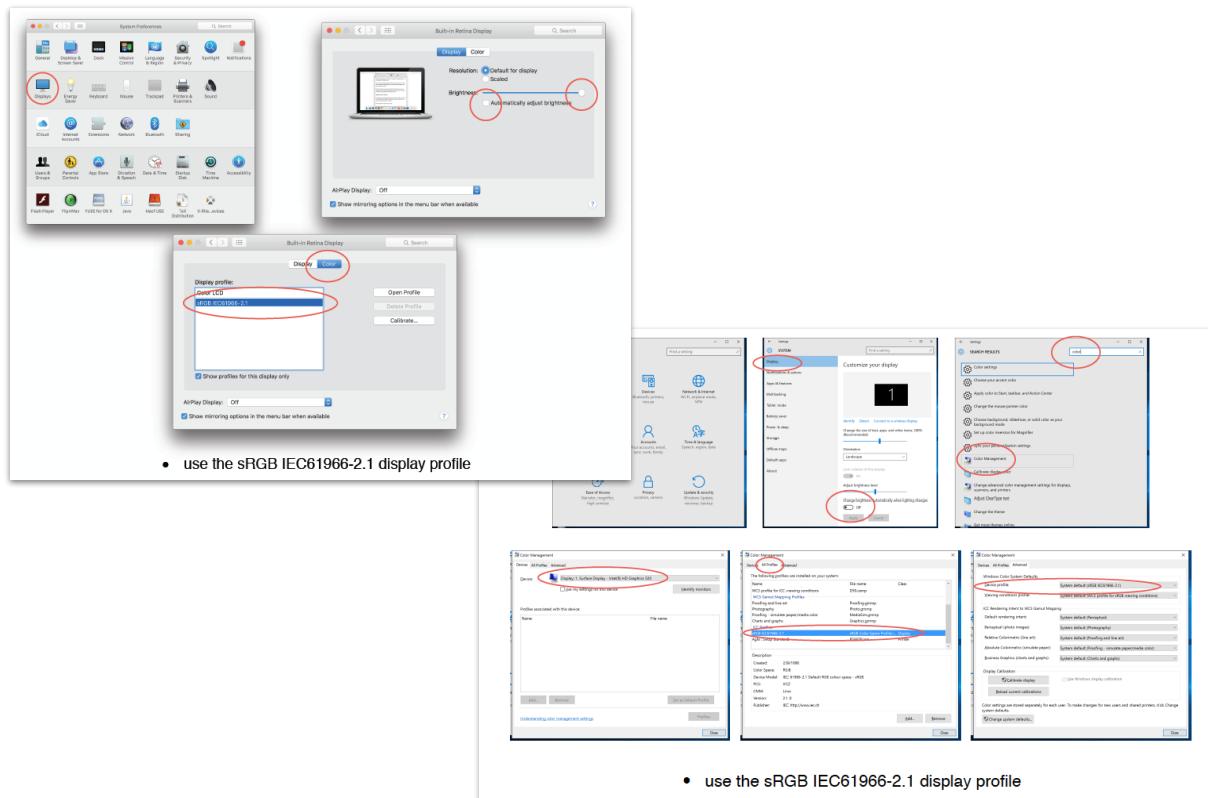
Hit Esc or Q to give up, any other key to retry:

/ to check measured values use... */*

dharma.local% **cat 31_CM_XYZ_Labs_real.txt**

Reading X Y Z L* a* b*
1 27.631738 28.991121 14.465498 60.773792 -1.273581 20.422921
2 17.958480 20.337288 8.121868 52.216432 -8.493803 25.262133

3) (Re)-set your display to the standard settings you set up in Project 1 step 3.



4) a) Display the “patches.jpg” image you created in Project 1 on your laptop. Follow the instructions below to use the ColorMunki “spotread” function to measure the colorimetric values and reflectance spectra of these imaged color patches. You will need to use the ‘-t’ flag with “spotread” and calibrate the instrument to a white patch on your display before measuring the emission spectra of the displayed patches. b) Save the data.

```
/* need to include the -t flag to measure screen patches */
dharma.local$ spotread -t 31_XYZ_Labs_imaged.txt

Spot read needs a calibration before continuing
Set instrument sensor to calibration position,
and then hit any key to continue,
or hit Esc or Q to abort:

/* create a white patch onscreen to use as the */
/* 'source' for calibration */
Place the instrument on its transmissive white source,
and then hit any key to continue,
or hit Esc or Q to abort:
Warning: Transmission light source is low at some wavelengths!
Calibration complete

Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take
a reading:

Result is XYZ: 18.217468 18.388513 9.602670, D50 Lab:
49.963981 2.581140 16.076209

Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to
take a reading: s

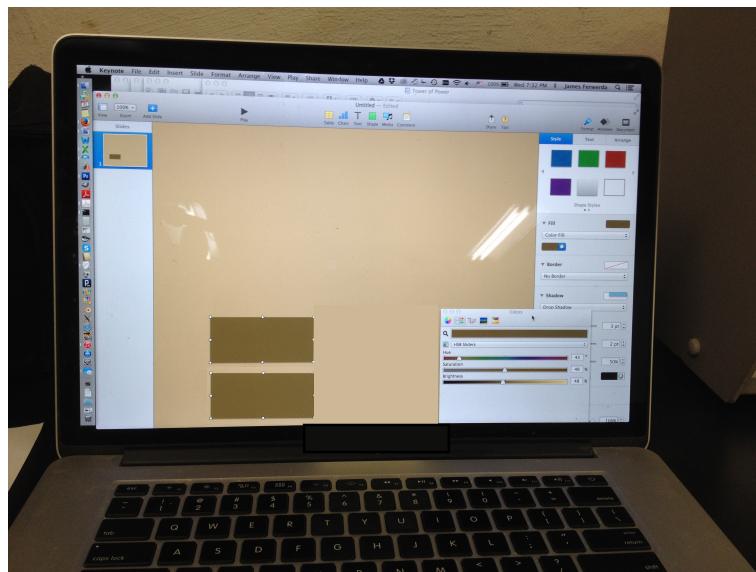
Enter filename (ie. xxxx.sp): 31.2_imaged.sp
Writing file '31.2_imaged.sp' succeeded

Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take
a reading: Q

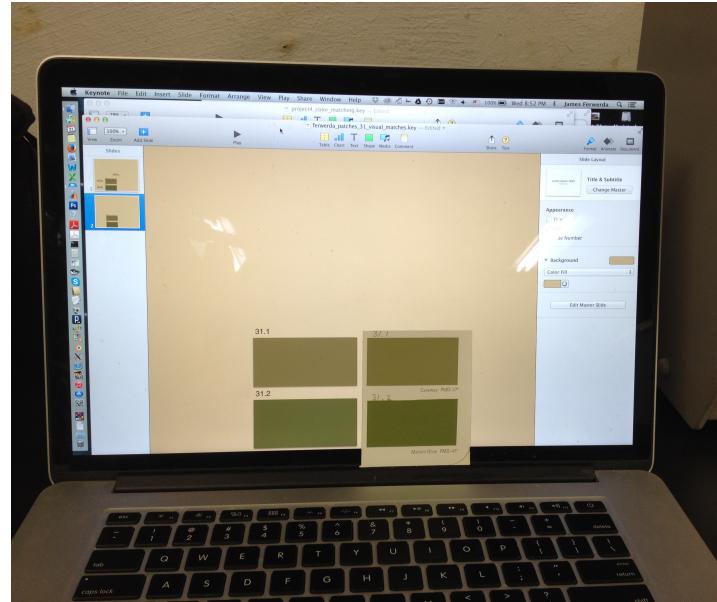
Spot read stopped at user request!
Hit Esc or Q to give up, any other key to retry:

/* to check measured values use... */
dharma.local$ cat 31_CM_XYZ_Labs_imaged.txt
Reading   X      Y      Z      L*      a*      b*
1       14.679720 15.144213 7.352593 45.831089 0.471699 17.265917
2       6.592598  7.394273 2.858245 32.688137 -5.406671 18.742793
```

5) Using your favorite method (mine is Keynote), create two adjustable color patches on your laptop display. The patches should be the same size as your real color patches. They should be shown on a background that has approximately the same color and intensity as the background of your real patches.



6) a) Place your laptop in the D50 light booth and hold or tape your real patches next to the screen patches. b) Adjust the upper screen patch values until you achieve a visual match to your real #.1 patch. c) Repeat for your #.2 patch. d) Take a picture of this setup save it as a high-quality JPEG image named “(team#)_(patch#)_real_vs_matching.jpg” and include the image in your report.

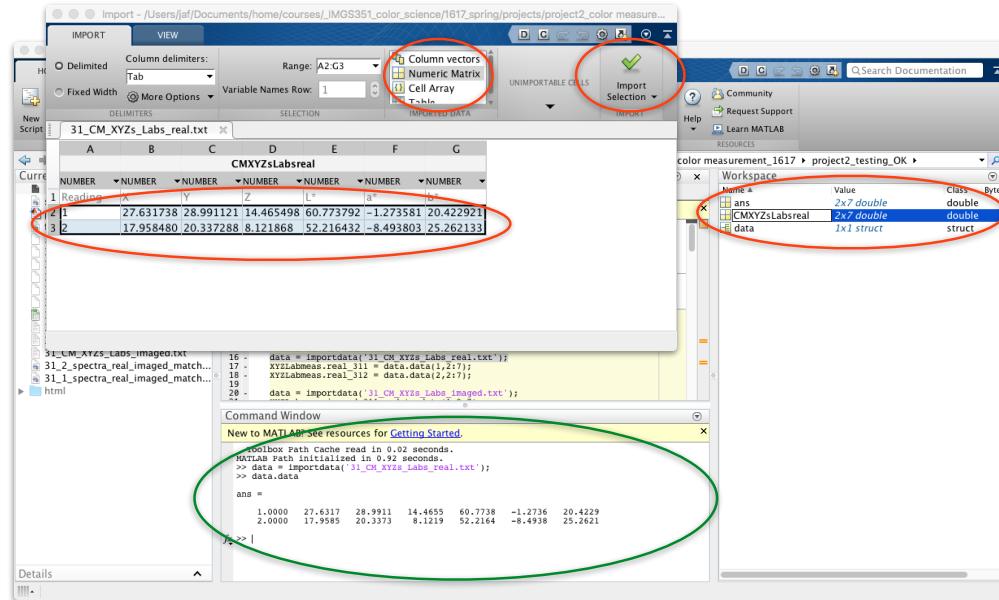


team0_31_real_vs_matching.jpg

7) a) Use the ColorMunki with the spotread -t command to measure the colorimetric values and emission spectra of the matching screen patches. b) Save the data.

```
dharma.local% spotread -t 31_CM_XYZ_Labs_matching.txt
...
Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take a reading:
Result is ...
Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take a reading: s
Enter filename (ie. xxxx.sp): 31.1_matching.sp
Writing file '31.1_matching.sp' succeeded
Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take a reading:
Result is ...
Place instrument on spot to be measured,
...
Hit ESC or Q to exit, instrument switch or any other key to take a reading: s
Enter filename (ie. xxxx.sp): 31.2_matching.sp
Writing file '31.2_matching.sp' succeeded
Hit ESC or Q to exit, instrument switch or any other key to take a reading: Q
dharma.local% cat 31_CM_XYZ_Labs_matching.txt
Reading   X      Y      Z      L*      a*      b*
1     15.933021 15.848903 4.813733 46.775627 3.791958 30.658525
2     7.423362  8.017091 2.596498 34.018455 -2.890080 23.090820
```

8) Import the colorimetric measurements of the real, imaged and matching patches into MATLAB from the .txt files you created in steps 2,3, and 6. This can be done using the “Home->Import Data...” menu command which opens the dialog shown below. Select the datafile you want to import, set the mode as Numeric Matrix, and click “Import Selection”. The data will appear in your workspace as a 2x7 array of doubles where the rows represent the XYZ and Lab values of the two patches You can rename the data after it’s imported. The data can also be imported as a structure using the “importdata” command as shown below.



9) a) Create a MATLAB script that prints a formatted table like the one shown below of the measured XYZ and Lab values of your real, imaged, and matching patches. You will need to use the “fprintf” command. Reading the fprintf documentation on the %t, %n, %s, %d, and %f formatting strings will be useful. b) Confirm for yourself that all the values bear some reasonable correspondence to the patch colors (i.e. there are no glaring errors in measurement or calculation). c) Include a listing of your matlab code and a screenshot of the final table in your report.

```
% print formatted tables of measured XYZs and Labs
% for the
fprintf(1, 'your code here')

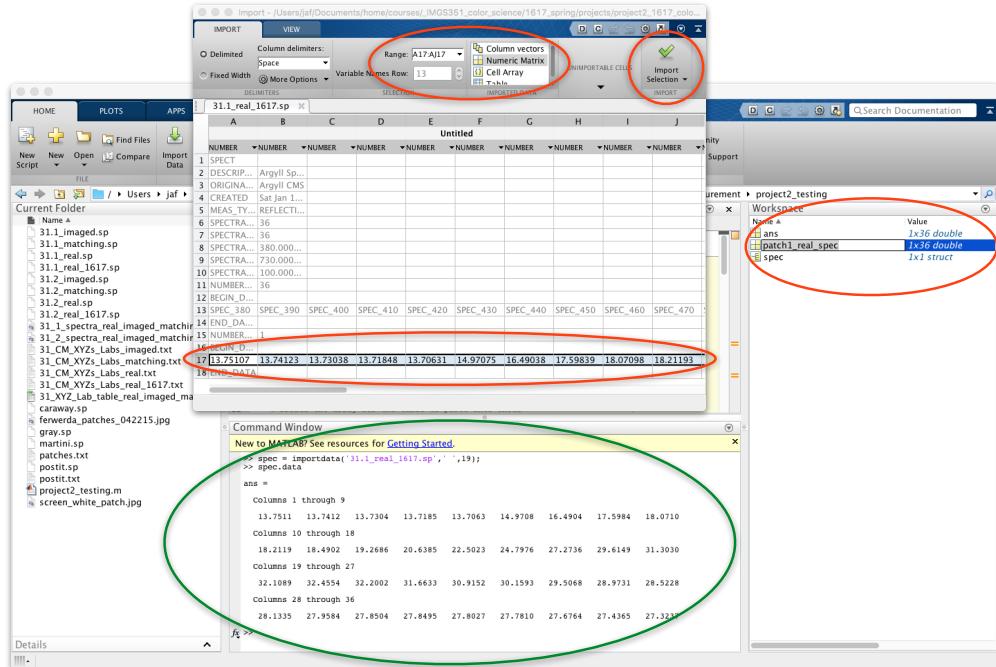
fprintf(
fprintf(
b\n');
fprintf(
'rea
fprint(
'im
fprint(
'mat
fprintf(
'mat
fprintf(
fprint(
b\n');
fprintf(
'rea
fprint(
'im
fprint(
'mat
```

hint: table can easily be made with
one or fewer fprintfs per table row

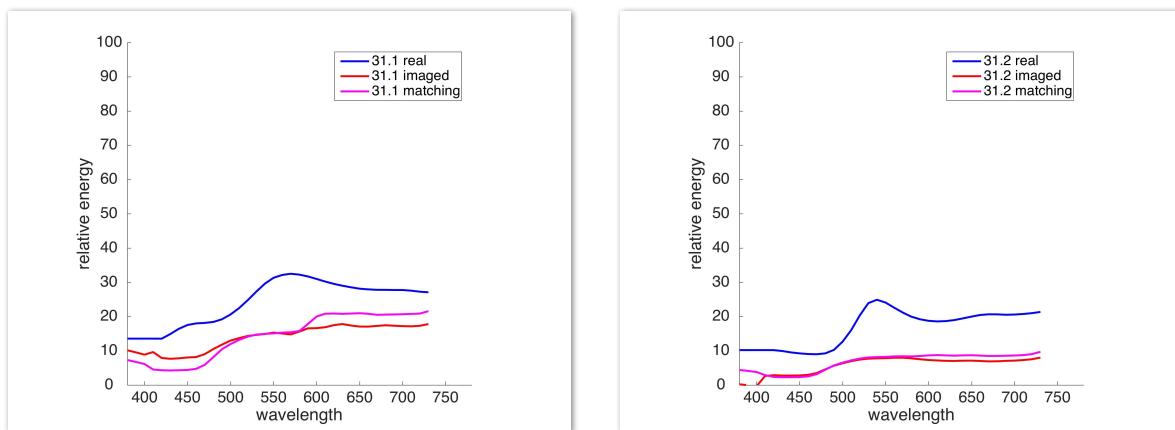
Measured XYZ and Lab values						
	patch 31.1					
	X	Y	Z	L	a	b
real	27.6317	28.9911	14.4655	60.7738	-1.2736	20.4229
imaged	14.6797	15.1442	7.3526	45.8311	0.4717	17.2659
matching	15.9330	15.8489	4.8137	46.7756	3.7920	30.6585

patch 31.2						
	X	Y	Z	L	a	b
real	17.9585	20.3373	8.1219	52.2164	-8.4938	25.2621
imaged	6.5926	7.3943	2.8582	32.6881	-5.4067	18.7428
matching	7.4234	8.0171	2.5965	34.0185	-2.8901	23.0908

10) Import the spectral measurements of the patches into MATLAB. This can be done using the “Home->Import Data...” menu command which opens the dialog shown below. Select the data you want to import, set the mode as Numeric Matrix, and click “Import Selection”. The data will appear in your workspace as a 1x36 array of doubles corresponding to relative spectral energy (normalized to 100) measured every 10nm from 380-730nm. You can rename the data after it’s imported. The data can also be imported using the “importdata” command as shown below.



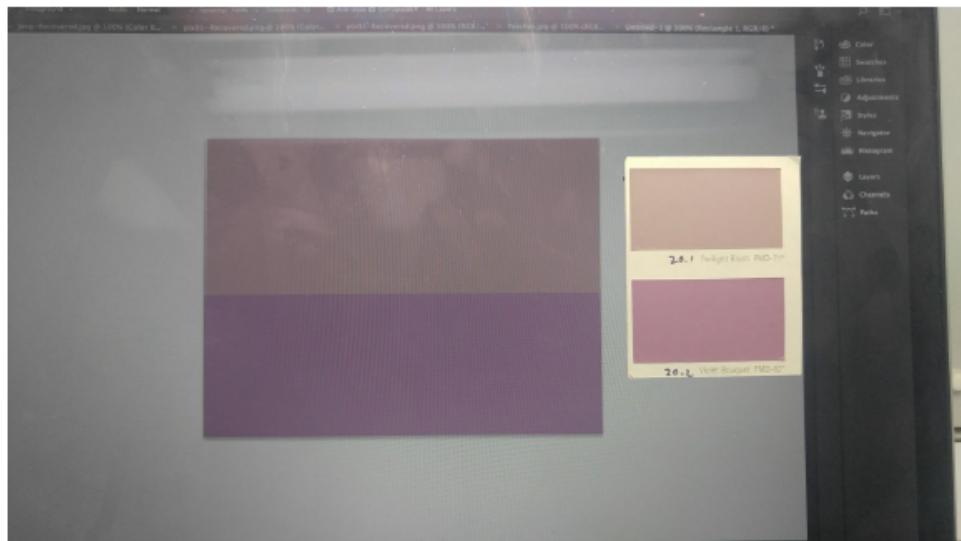
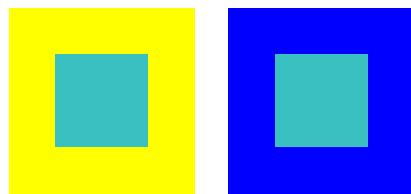
11) a) Use MATLAB to create two graphs like the ones shown below that plot the spectra of the real, imaged, and matching patches on the same axes. The axes should be scaled as shown (380-780 wavelength, 0-100 relative energy). Label the axes and include legends that identify the different curves. b) Confirm for yourself that the plotted curves bear some reasonable correspondence to the patch colors (i.e. there are no glaring errors in measurement or calculation). b) Save the graphs as image files and include them in your report.



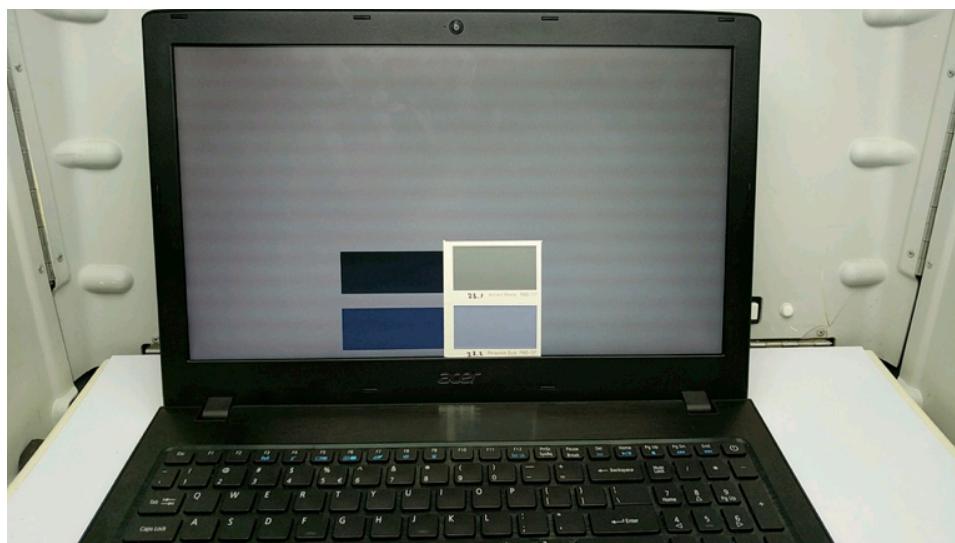
12) Submit your results using the “teamX_project2_report.docx” template in myCourses.

Project 2 post-mortem

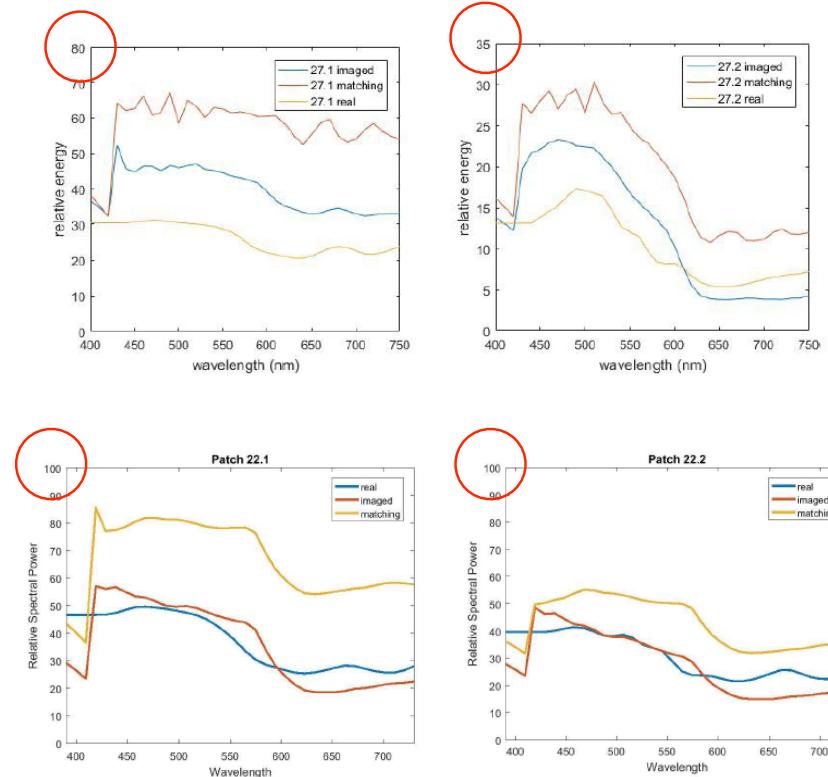
size and bg matter in color matching



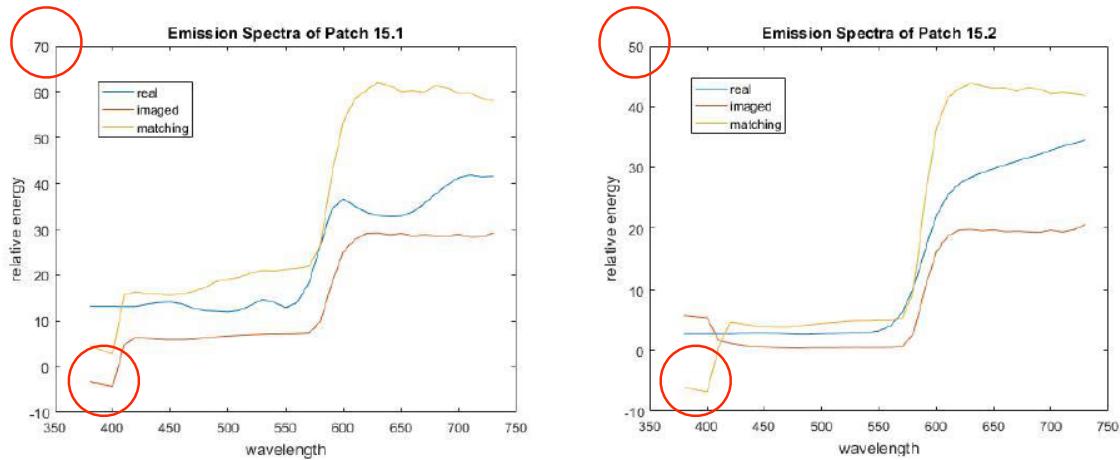
best possible match?



use consistent axes so data can be compared visually

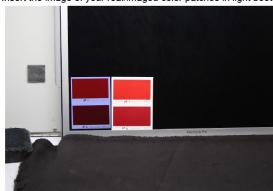


reality check: negative emissions?



reality check: L,a,b, of 100,0,0?

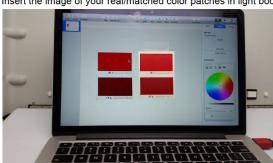
Insert the image of your real/imaged color patches in light booth from Project 1, step 6)



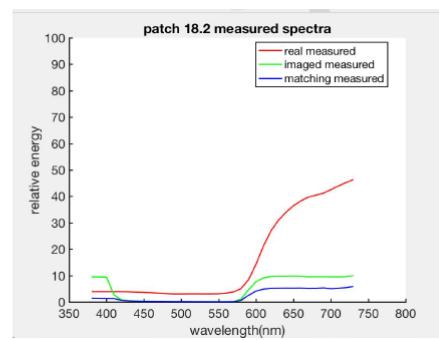
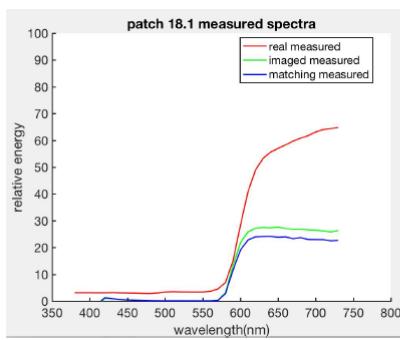
Measured XYZ and Lab values

	Patch 18.1					
	X	Y	Z	L	a	b
real	98.9291	102.4831	84.1114	100.9523	0.1949	0.3404
imaged	13.0037	6.5770	0.4764	30.8238	54.5839	44.1502
matching	11.0303	5.5770	0.3078	28.3193	51.6910	43.0142

Insert the image of your real/matched color patches in light booth from Project 2, step 5)

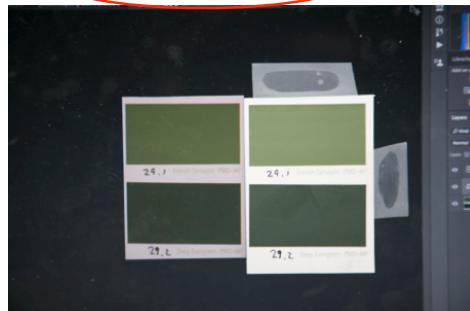


>>



read/follow instructions, do all tasks

Insert the image of your **real/imaged** color patches in light booth from Project 1, step 4)



Insert the image of your **real/matched** color patches in light booth from Project 2, step 6)

