- All your code should be in the `src` directory and images in `imgs` directory.

- Do not use any external library other than **numpy** for implementing any of the tasks. You can however use external libraries for I/O operations and plotting. If you are not sure if a library is allowed for a particular task, clarify with your TAs.

- You will be evaluated on correctness and how vectorized your code is - with correctness being the priority.

- Write modular code with relevant docstrings and comments for you to be able to use functions you have implemented in future assignments.

- All theory questions and observations must be written in a markdown cell of your jupyter notebook.

- All academic integrity policies apply. Check the course web page for more clarity.

- Start the assignment early, push your code regularly and enjoy learning!

1   Michael Scott's Storage Conundrum (15 Points)

In the popular sitcom **"The Office (US)"**, Michael Scott, the world's best boss (a title given to him by himself) likes to capture the little moments that he has with the employees of the Dunder Mifflin Company. He has planned a trip for the employees and would like to take many pictures during the trip. Help the IT guy of the Dunder Mifflin company, answer Michael Scott's queries.

1. **(4 Points)** Before he can trust you, Michael Scott wants to verify if you actually know how images are stored. He points to a coloured image of size 5.76 MB with an aspect ratio of 4:3. He wants you to calculate the height and width of the image in terms of number of pixels. Give him the right answer so that he can build trust in you.

2. **(6 Points)** Now that he has gained trust in you, he tells you that during the trip, he will be capturing images of square shape, with a width of 5200 pixels. He also estimates that he would take a maximum of 2000 images during the trip. He wants to know the *minimum* number of memory cards of size 64 GB he should carry in order to be able to store these images without having to delete any of them if the images were

(a) Black and White images (0 for black and 1 for white)

(b) Gray scale images

(c) Colored images

3. **(5 Points)** Andy and Dwight want to advertise Dunder Mifflin's low prices using a bill board. They made a poster on their desktop. Because they did not know about the concept of resolution - they were satisfied with how it looked on their desktop - to them it was high resolution. However they were able to see individual pixels when they printed the bill board. What might have gone wrong? Michael Scott wants you to explain to them in detail what they might have done wrong with examples.

Note: For the above questions assume that the raw bytes of the images are being stored without any kind of compression. (In reality this is not the case. Image compression techniques will be covered later in the course). Also assume standard intensity range of $0-255$ per pixel per channel, unless otherwise mentioned. For the above problems write down the calculations in your jupyter notebook with sufficient intermediary steps.

2   Threat Level Midnight (20 Points)

Michael Scott is a well-known name in and around Dunder Mifflin. He's trying to make a promotional poster for his upcoming blockbuster movie, **Threat Level Midnight**. As expected, he has no idea what he's doing. He needs your help to take an image of him on a green screen and graft it onto a fake background image. This task is commonly known as **chroma-keying**. How does the green screen help in this case?

(a) foreground image   (b) background image   (c) result

1. **(5 Points)** Write a function that takes a color image and finds the most frequently occurring color from the image.

2. **(15 Points)** Write a function `mergeImage` which takes two images `fg` and `bg` that extracts the foreground object and places it in the background and returns the resultant image. Test your implementation using the provided foreground (foreground.png) and background (background.png) images.

3 Broken Copier and Linear Transforms (30 Points)

Dunder Mifflin recently bought a new fancy and expensive copier for office use, but setting it up was too much trouble. Pam was left in charge of getting it up and running. After spending over four hours, she successfully got almost everything to work. The copier is expensive because it is supposed to be able to transform greyscale levels of images before it copies them. But no matter how hard Pam tried, she couldn't get it to do that. She's not very good at Digital Image Processing so she needs your help doing this.

1. **(10 Points)** Write a function `piecewiseLinTransform` that implements a piecewise linear transform defined by

$$g(z) = K_1^i \cdot z + K_2^i \; ; \; a^i \leq z \leq b^i$$

   where, z is the input intensity (generally ranging from $0 - 255$) and i corresponds to the ith piecewise linear transform. The function takes an input greyscale image, coefficients K_1 and K_2 , and intervals $[a, b]$ for each linear segment and should output the transformed image.

2. **(10 Points)** Run the images through `piecewiseLinTransform` on pam1.png and pam2.png. The piecewise functions to be used are given for each image.
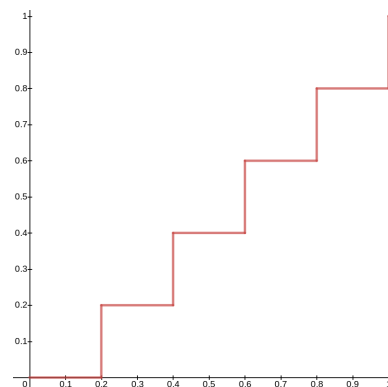

(a) pam1.png
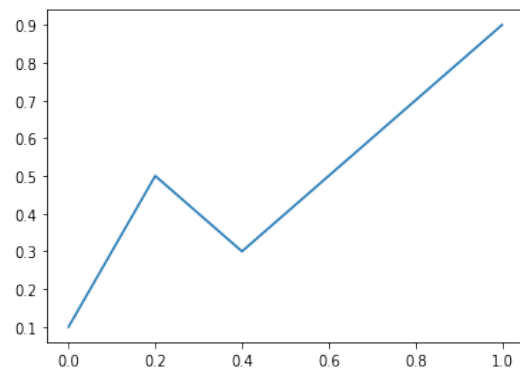
(b) plot1.png

(c) pam2.png

(d) plot2.png

3. **(10 Points)** Choose a photo of your interest, convert it to grayscale, and run `piecewiseLinTransform` using any *custom* piecewise linear function that you like. Plot the function used.

   Make sure to explain all your steps in detail so that Pam can do this on her own next time.