Exercise 8.6

1. Estimate the mean and standard deviation for the plot in Figure 8.4.

   Solution.

   - Mean: 68 inches
   - Standard Deviation: 5 inches

   ■

2. Estimate the mean and standard deviation for the plot in Figure 8.5.

   Solution.

   - Mean: \$30,000
   - Standard Deviation: \$10,000

   ■

3. What is the mean and standard deviation of this data set.

   {1, 3, 1, 3, 1, 3, 1, 3, 1, 3, 1, 3, 1, 3, 1, 3, 1, 3, 1, 3}

   Solution.

   - Mean: 2
   - Standard Deviation: 1

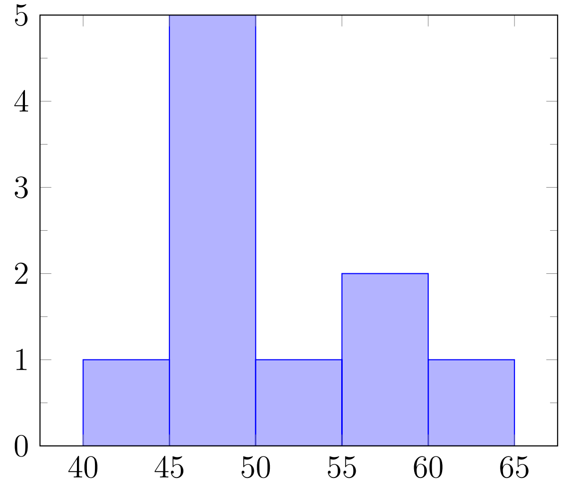
   ■

4. Begin by considering the simple dataset of the high temperatures in Needham for ten days in March:

   $$T = \{57, 61, 46, 43, 46, 46, 54, 46, 46, 55\}$$

   (a) By hand, create a histogram of this data. What size bin makes sense? What bin centering makes sense?

   Solution.



∎

(b) By hand, compute the mean temperature over these ten days.

Solution.

$$\mu = 50$$

∎

(c) By hand, compute the variance and standard deviation of the temperature over these ten days.

Solution.

$$\sigma^2 = 37.78$$
$$\sigma = 6.15$$

∎

(d) This dataset has a flaw: it has a small number of datapoints. What do you see as the possible effects of having such a small sample?

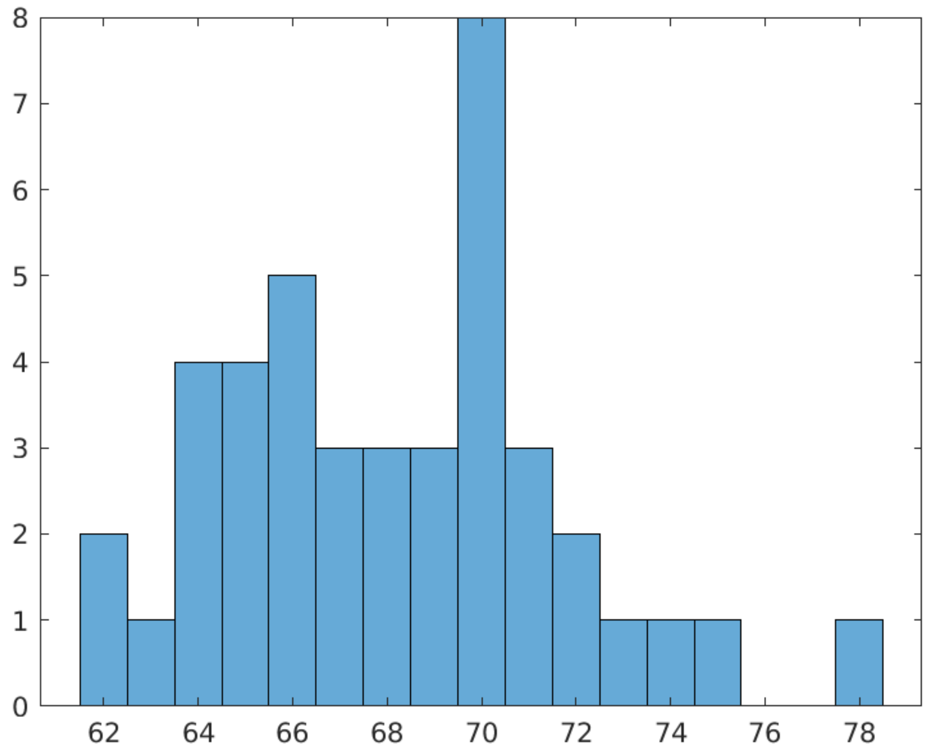
Solution. The small dataset may not truly capture the overall data. This is mostly because it is easily biased, especially by the means of collecting data. ∎

5. Now consider the larger dataset below of the approximated heights of the Olin faculty, measured in inches.

$$H = \{63, 66, 71, 65, 70, 66, 67, 65, 67, 74, 64, 75, 68, 67, 70, 73, 66, 70, 72, 62, 68, 70, 62, 69, 66, 70, 70, 68, 69, 70, 71, 65, 64, 71, 64, 78, 69, 70, 65, 66, 72, 64\}$$

(a) Computationally histogram this data.

Solution.



■

(b) Computationally, find the mean, standard deviation, and variance of this dataset.

Solution.

$$\mu = 68.1429$$
$$\sigma^2 = 12.7596$$
$$\sigma = 3.5721$$

■

Exercise 8.7

1. Load an image of your choice into MATLAB using the `imread` command. Display the image using the 'image' command.

Solution.

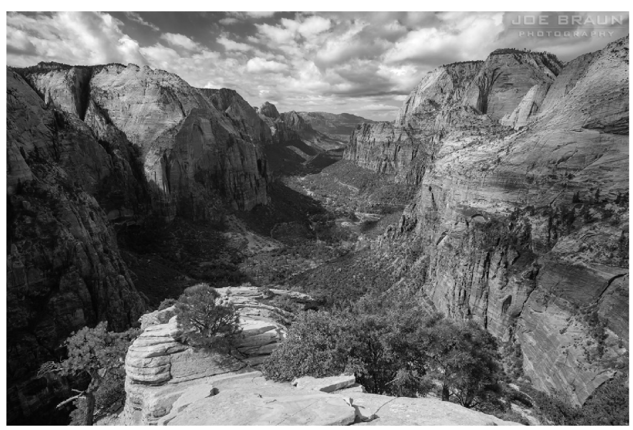
```
X = imread('angelslanding.jpg');
imshow(X);
```

∎

2. Convert your image to grayscale using the `rgb2gray` command.

Solution.

```
X_gray = rgb2gray(X);
imshow(X_gray);
```



∎

3. Convert your image to grayscale using the `rgb2gray` command.

Solution.

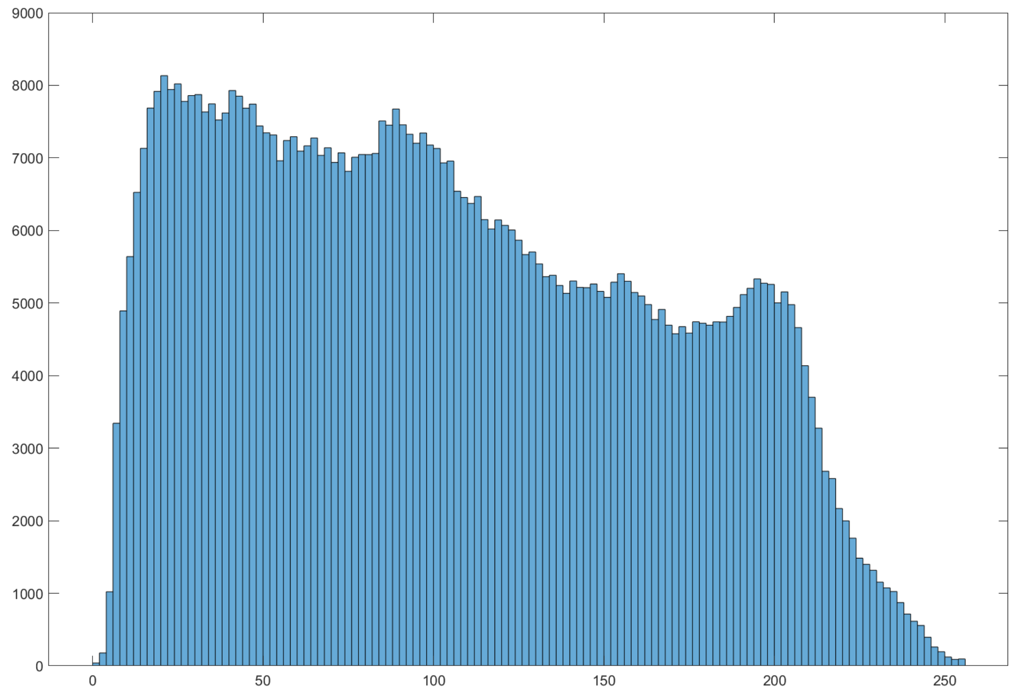
```
X_col = reshape(X_gray, [], 1);
```

∎

4. Make a histogram of the intensity values in your image. Does your image use the entire range of values from 0 to 255? What is the minimum pixel value used? What is the maximum?

Solution.

```
histogram(X_col)
```



Fortunately, it looks like the image is well-centered and distributed. ■

5. Find the mean of the intensities in your image data. Find the standard deviation. Is the intensity data well-centered on the available range? The location of the intensity data in the range determines the brightness of the image. How does the standard deviation compare to the available range? Does the intensity data span a good portion of the available range? This affects the contrast.

Solution.

```
X_mean = mean(X_col)
X_std = std(im2single(X_col))
```

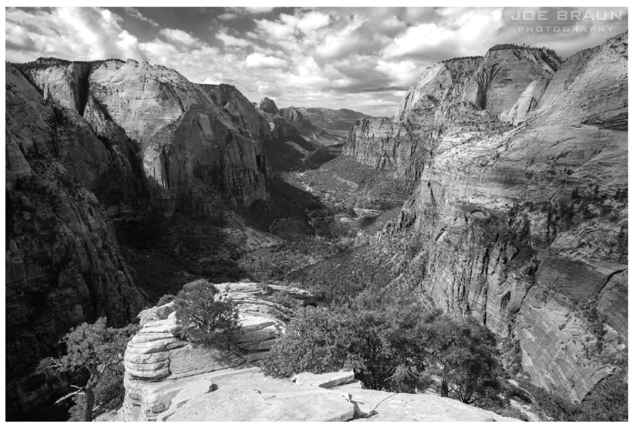
$$\mu = 103.9971$$
$$\sigma = 0.2412$$

■

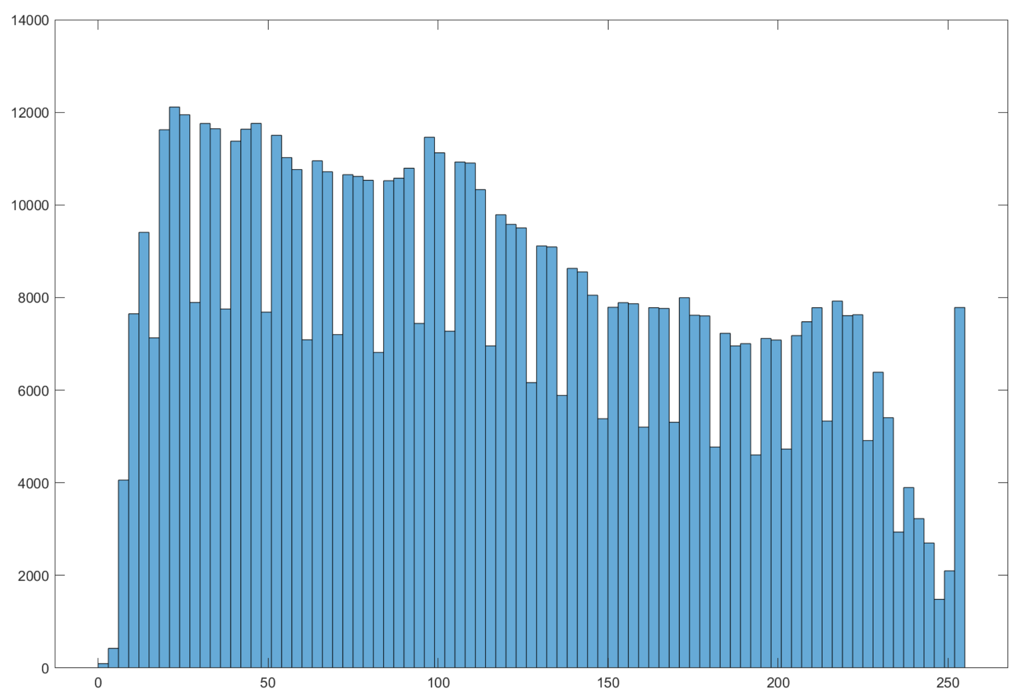
6. To adjust the brightness of your image, you can scale all of the intensity values by a multiplicative factor down (towards darker values) or up (towards brighter values). Based on looking at the histogram, should your image be brightened? Dimmed? Why?

Solution. The original image looks fairly well distributed, but is slightly skewed to the left. This can be adjusted by slightly increasing the intensity.

```
X_gray_adj = X_gray * 1.1;
imshow(X_gray_adj)
```




```
histogram(X_gray_adj)
```



The intensity histogram looks a lot more well distributed with a factor of 1.1, but it also indicates a significant amount of saturation. My guess of where that saturation is in the clouds. ■

7. To adjust the contrast, you make a linear mapping of the existing range onto the full 0 to 255 range. In other words, if you think of the current intensity value as your independent variable x, and the new intensity value as the dependent variable y, a contrast adjustment is defined by a function $y = f(x)$. Propose an equation for a line which gives you the "best" range of y's, given the input intensity values in the image. You should be able to justify this based on the histogram of the image.

   Solution. While the contrast is acceptable, to maximize contrast, we can remap the 9 to 216 range to the full 0 to 255 range. This will also lead to more saturation but better contrast.

$$y = f(x)$$
$$f(x) = \frac{255}{216-9}(x-9)$$
$$f(x) = \frac{255}{207}x - 11$$

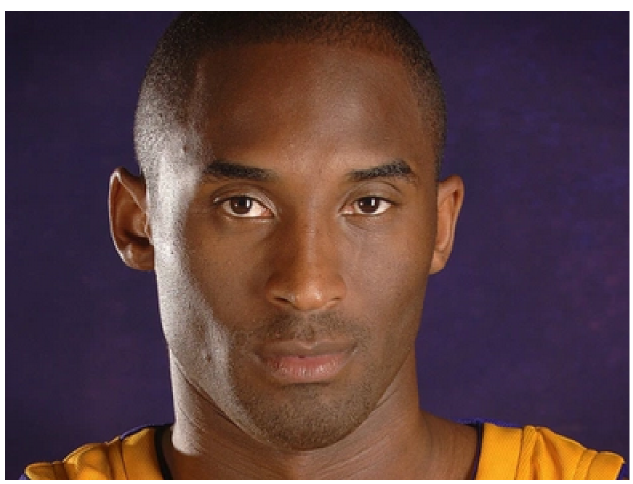
■

8. Implement brightness and contrast adjustment.

   (a) Load a picture of a face

   Solution.

```
face = imread('kobe.png')
```

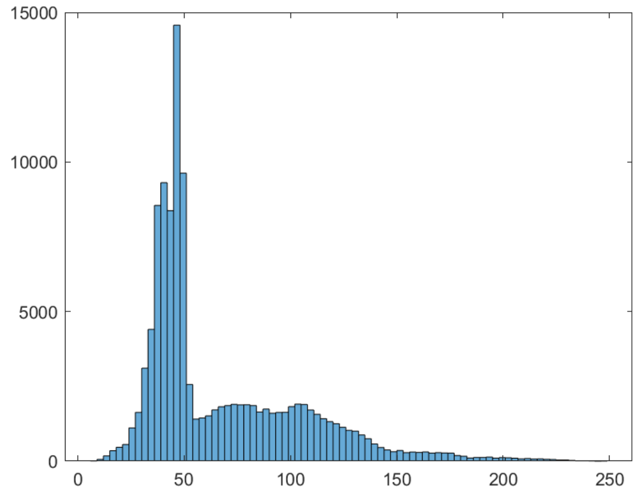


■

   (b) Analyze the intensity histogram.

   Solution.

```
face_gray = rgb2gray(face);
histogram(face_gray)
```

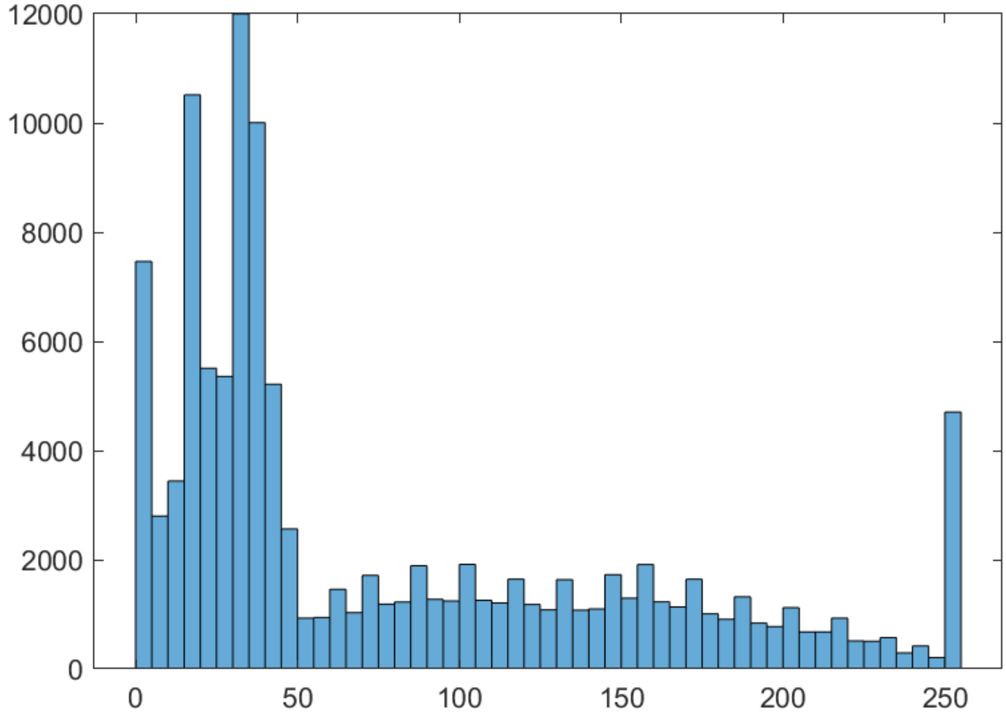


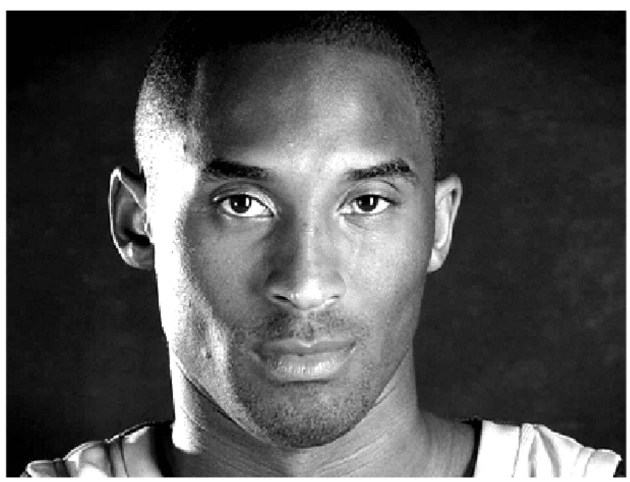
There is a clear skew to the left and spike at around 60. Much of this is probably the static background. ■

(c) Calculate the adjusted face by applying both brightness and contrast adjustments to make it as "good" as possible.

Solution.

```
face_gray_adj = (255/(150-30))*(face_gray - 30);
histogram(face_gray_adj);
imshow(face_gray_adj);
```





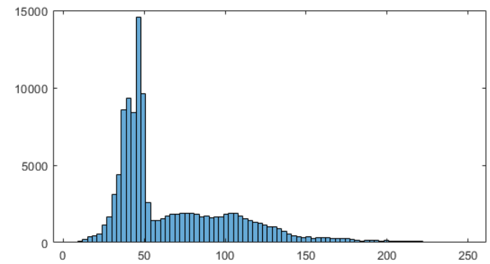
The contrast and intensity was adjusted to highlight the 30-150 range. ■

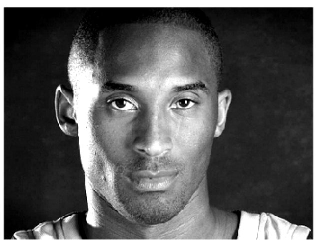
(d) Create a figure that includes four subplots: the original image, the original intensity histogram, the new image, and the new intensity histogram.

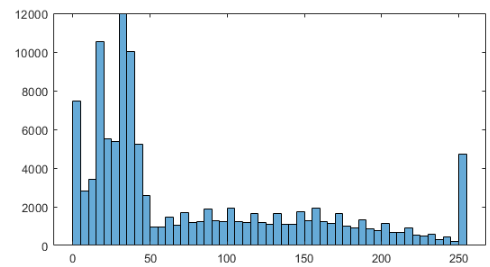
Solution.

```
subplot(2, 2, 1)
imshow(face);
subplot(2, 2, 2)
histogram(face_gray)
subplot(2, 2, 3)
imshow(face_gray_adj);
```

```
subplot(2, 2, 4)
histogram(face_gray_adj);
```







■

9. What would happen if the function for contrast adjustment was not linear? Why might you choose a non-linear function for this mapping?

   Solution. If the function for contrast adjustment was non-linear, certain intensity ranges would be highlighted significantly more than others. This could be advantageous, for example, if we only wanted to highlight the yellow in Kobe's shirt, in this case. ■