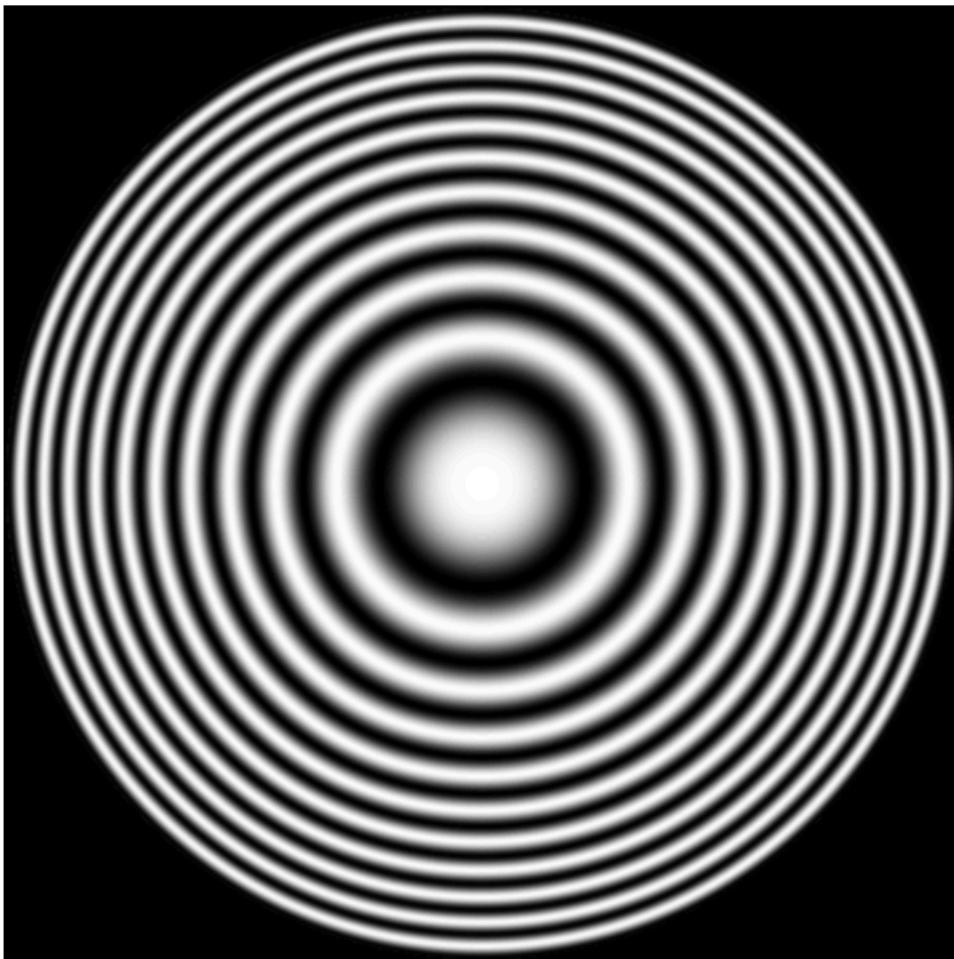


Assignment #2:

1. Load the image "zoneplate.tif" and display the image and it's histogram
2. What is the range of values present in the image?
3. Invert the image and print the inverted image and it's histogram

```
zplate=imread('zoneplate.tif');  
imshow(zplate)
```



```
imhist(zplate)
```

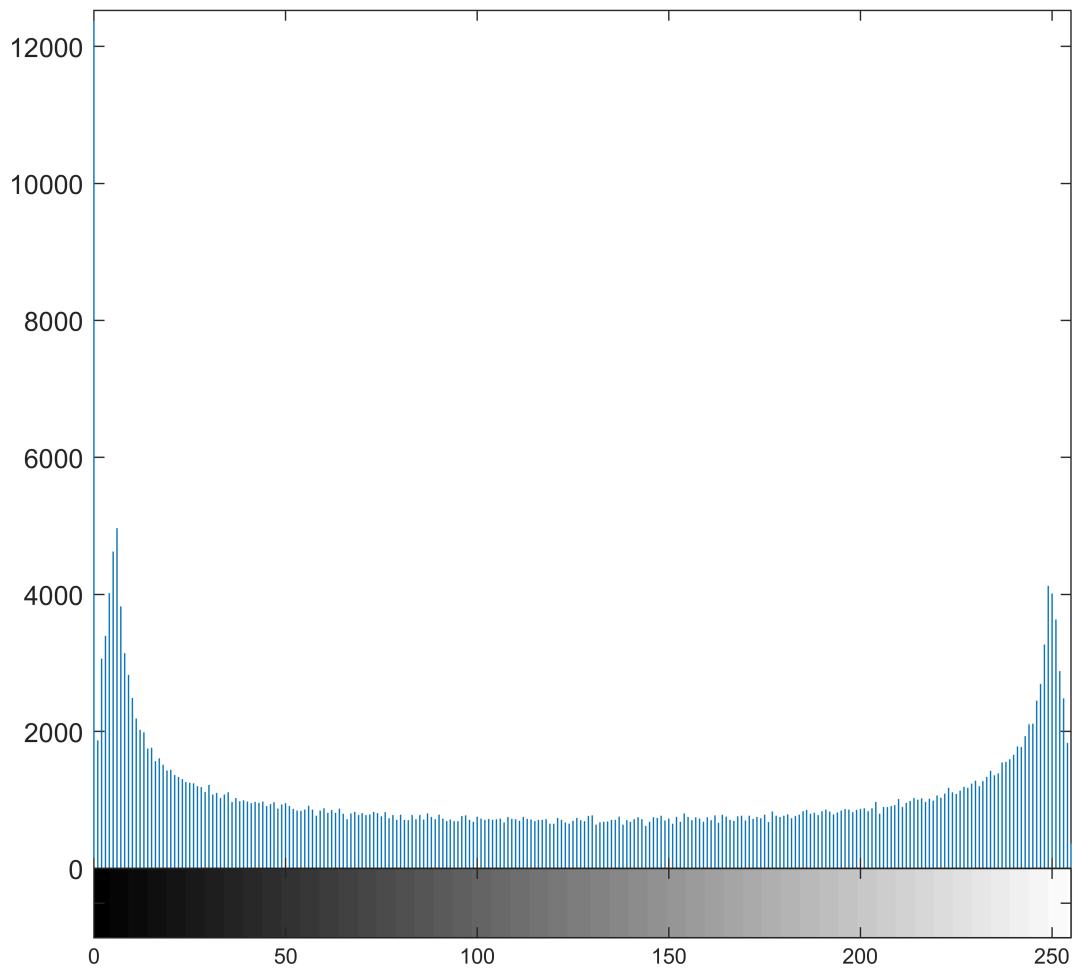


Image pixel range

```
Max_zplate=max(max(zplate)) % maximum of the rows and columns of the image.
```

```
Max_zplate = uint8
```

```
255
```

```
Min_zplate=min(min(zplate)) % minimum of the rows and columns of the image
```

```
Min_zplate = uint8
```

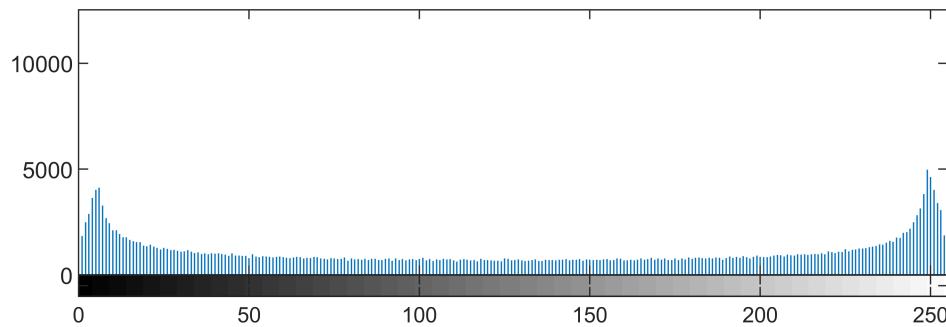
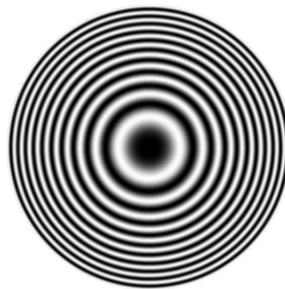
```
0
```

```
range_zplate=Max_zplate - Min_zplate % range of value present in the image
```

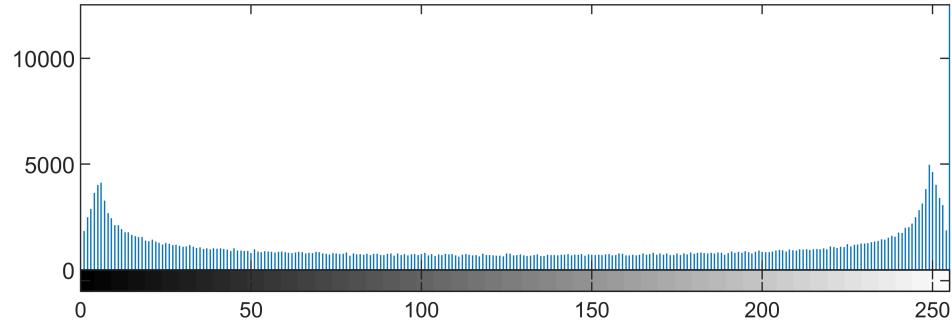
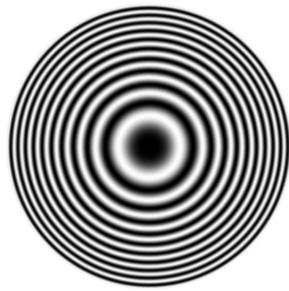
```
range_zplate = uint8
```

Image Invert

```
%% 3 Image invert
% method 1
zplate_inv=(Max_zplate-zplate);
figure
subplot(2,1,1)
imshow(zplate_inv)
subplot(2,1,2)
imhist(zplate_inv)
```



```
% method 2
X2 = imcomplement(zplate);
figure
subplot(2,1,1)
imshow(X2)
subplot(2,1,2)
imhist(X2)
```

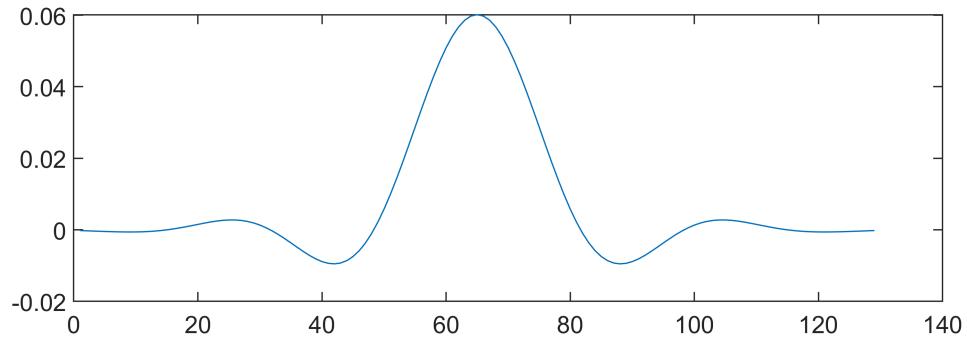
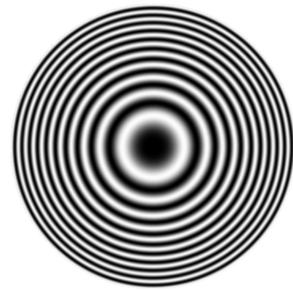


This will read in the coefficients of digital filters. These were designed using MATLAB's Signal Processing Toolbox and the `fir1` function, so these are finite impulse response filters (and therefore stable).

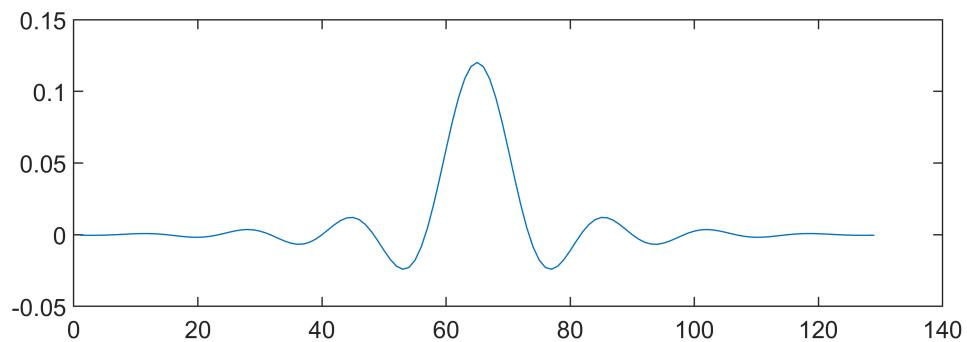
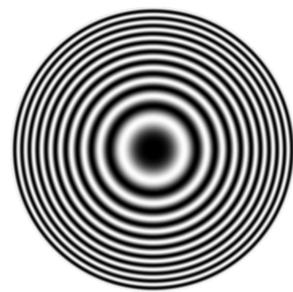
```
lp1=dlmread('oneDlowpass1.txt');  
lp2=dlmread('oneDlowpass2.txt');
```

4. Plot both lp1 and lp2.

```
plot(lp1)
```

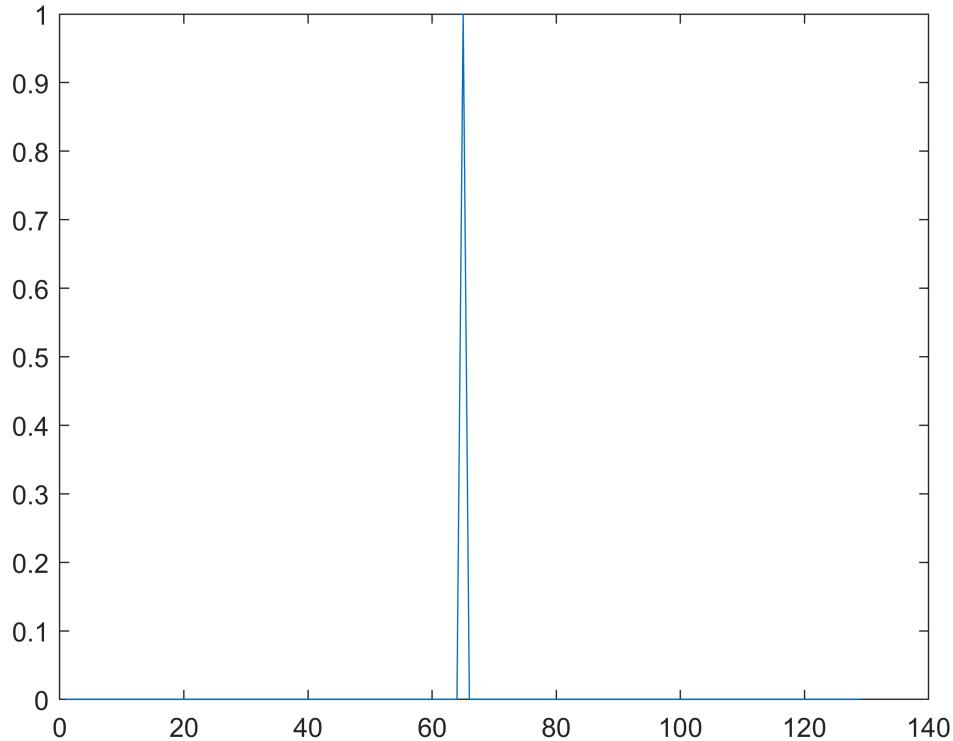


```
plot(lp2)
```



The following code will generate an impulse at the center of the length of the sequence. Note that the Fourier Transform of a unit impulse is the constant 1.

```
M_el=numel(lp1);
center=ceil(M_el/2);
oneDimpulse(1:M_el)=0;
oneDimpulse(center)=1;
figure, plot(oneDimpulse);
```



There are four main categories of filters:

1. low pass
2. high pass
3. band reject (notch)
4. band pass

These can all be generated from a low pass filter and an impulse of the the correct size:

High Pass: $HP = Impulse - LP$

```
HP1=oneDimpulse-lp1;
HP2=oneDimpulse-lp2;
```

Band Reject: $BR = LP + HP$

```
BR1=lp1+HP1;  
BR2=lp2+HP1;  
BR3=lp1+HP2;  
BR4=lp2+HP2;
```

Since the LP will have a lower "cutoff frequency" than the high pass filter, this can be written as (HP2 just indicates the cutoff frequency used is different from LP1):

Band Reject = LP1 + HP2

```
BR3;
```

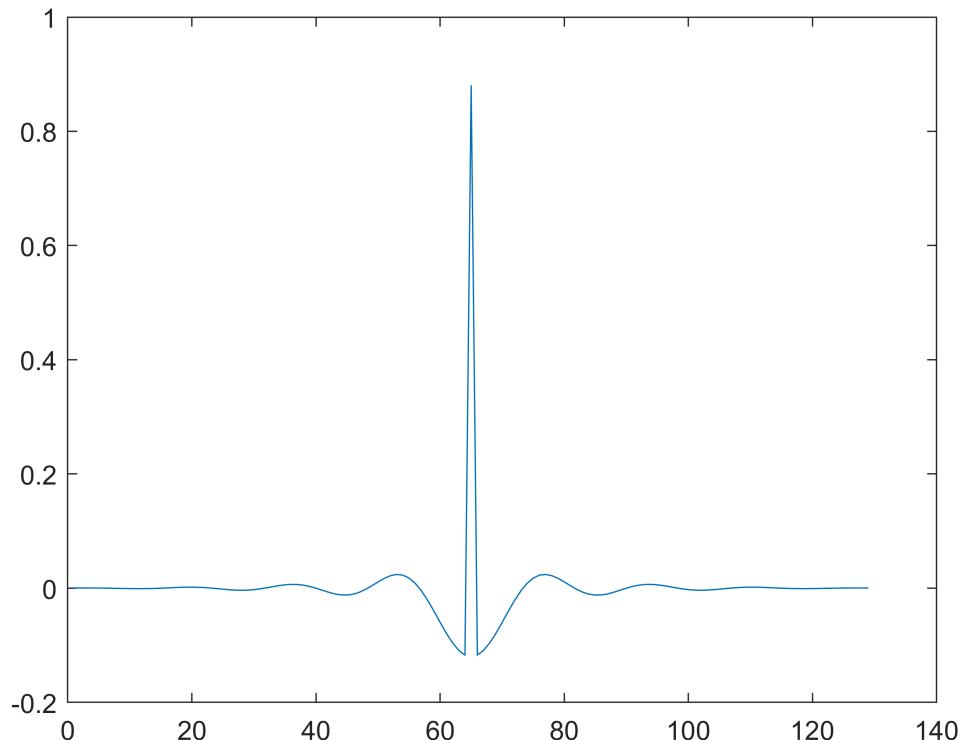
Band Pass = Impulse - Band Reject

```
BP=oneDimpulse-BR3;
```

5. Generate, using the given lp1 and lp2, the following filters: the impulse used must be the same length as the low pass filter used, in this case the oneDimpulse has the correct length.

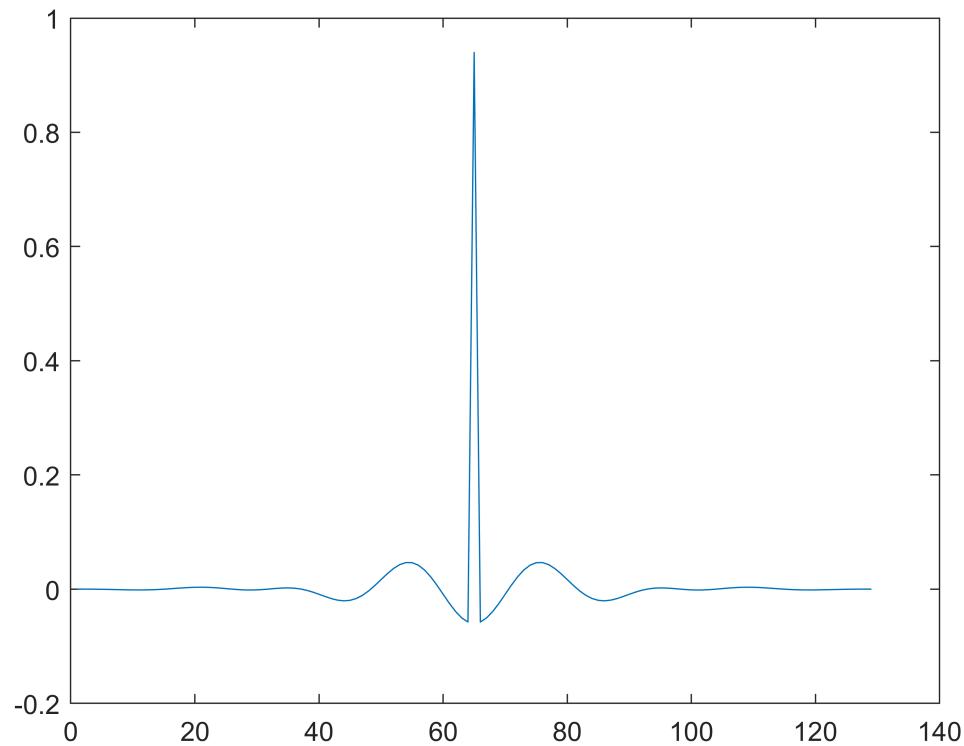
a. a high pass filter using lp2

```
plot(HP2)
```



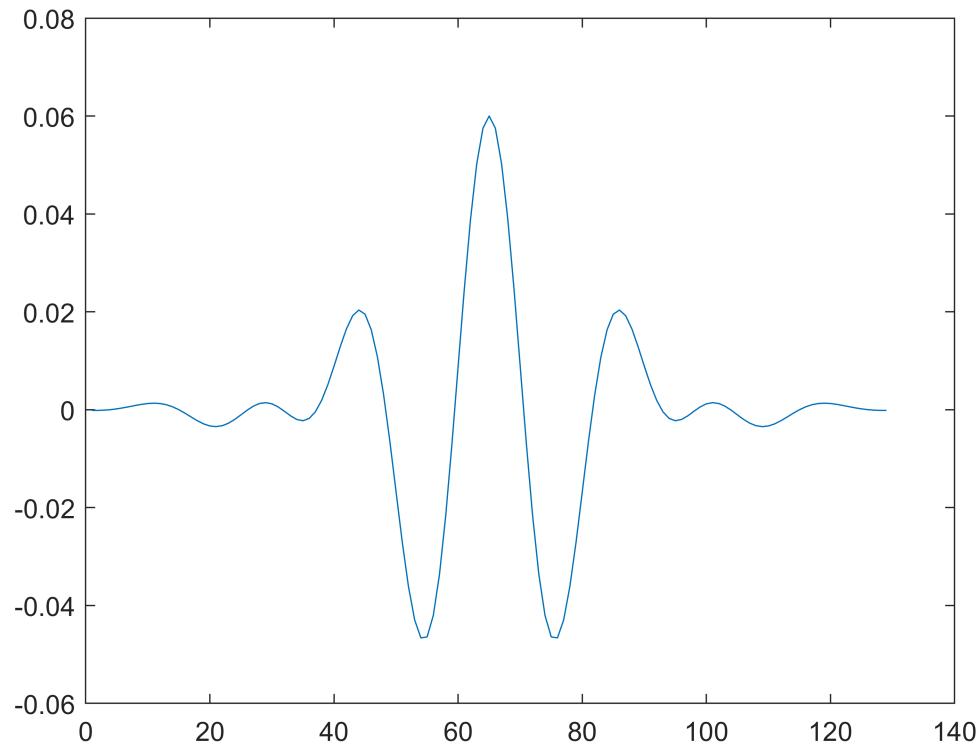
b. a band reject filter

```
plot(BR3)
```



c. a band pass filter

```
plot(BP)
```



6. There are several ways to generate a 2D filter from a given 1D filter. It's possible to just generate a square matrix by multiplying the two 1D filters together. This will work but will often generate ringing, so a windowing method is used to smooth the transition between edges of the image. MATLAB has a built in function that makes this easy: `ftrans2`

As an example: to generate a 2D low pass filter using the coefficients of the filter given in `lp1`:

```
LP1_2D=ftrans2(lp1);
figure, mesh(LP1_2D(1:2:end,1:2:end))
```

High Pass

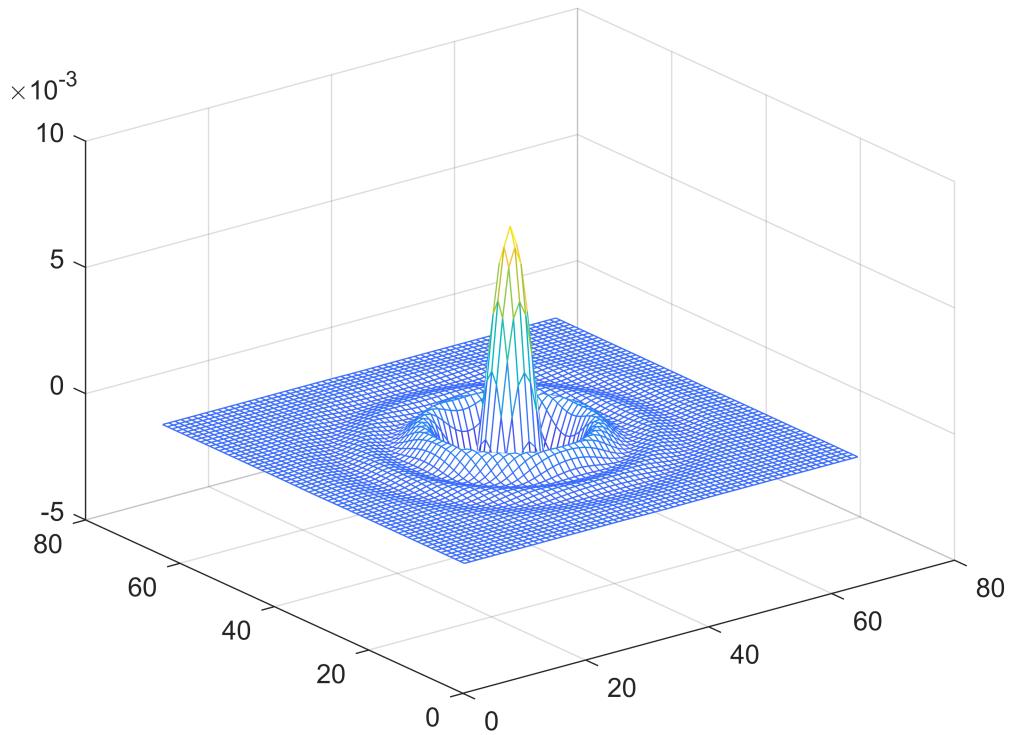
```
HP1_2D=ftrans2(HP1);
figure, mesh(HP1_2D(1:2:end,1:2:end))
HP2_2D=ftrans2(HP2);
figure, mesh(HP2_2D(1:2:end,1:2:end))
```

Band Reject

```
BR1_2D=ftrans2(BR3);
figure, mesh(BR1_2D(1:2:end,1:2:end))
```

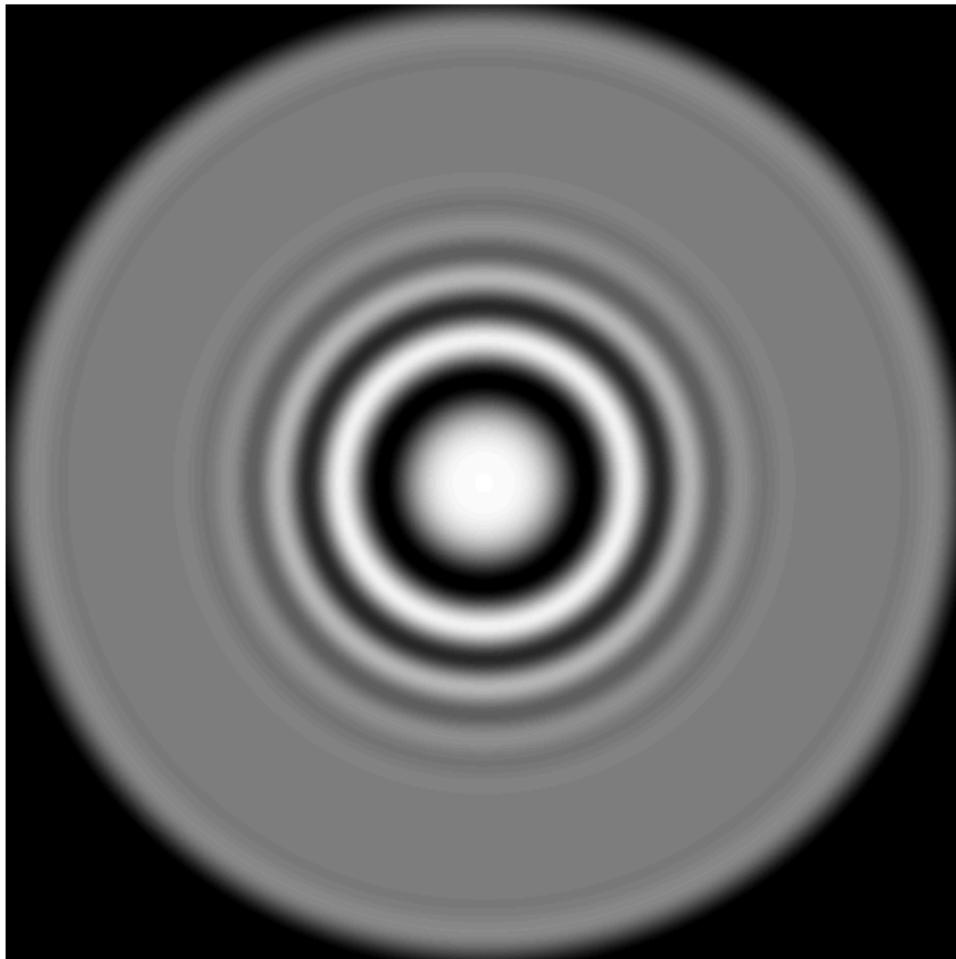
Band pass

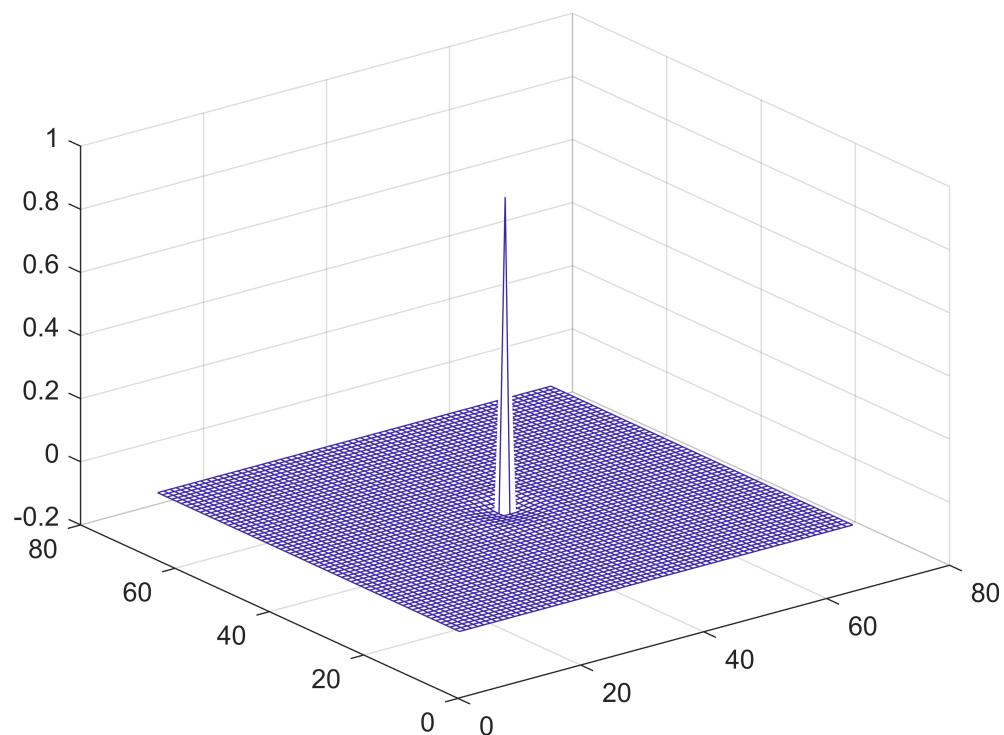
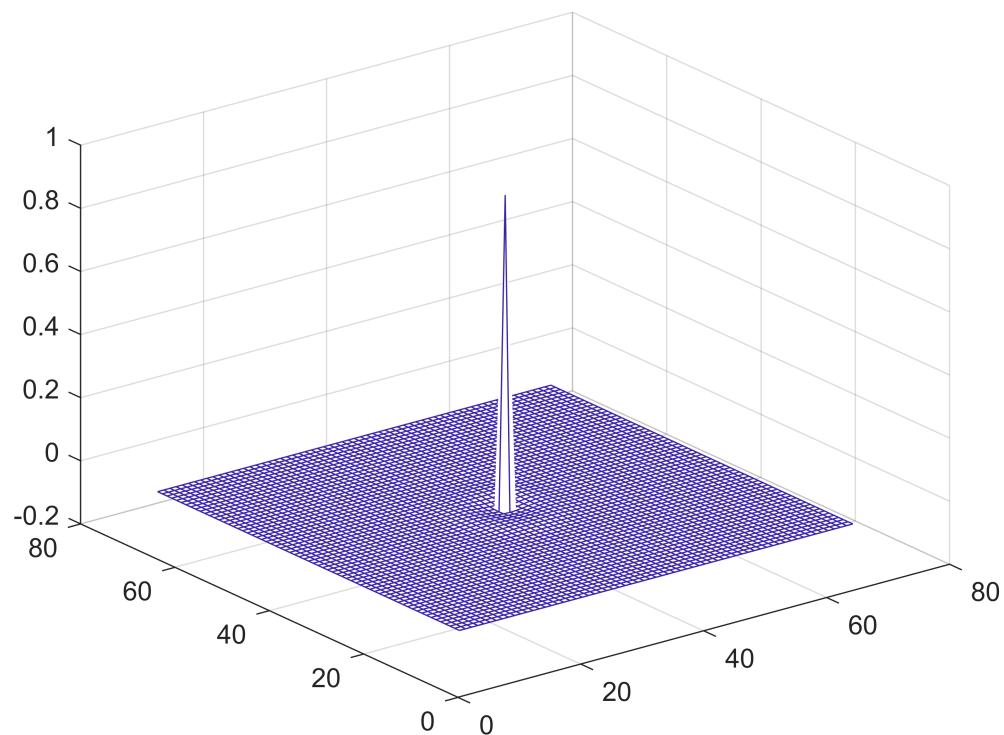
```
BP_2D=ftrans2(BP);
figure, mesh(BP_2D(1:2:end,1:2:end))
```

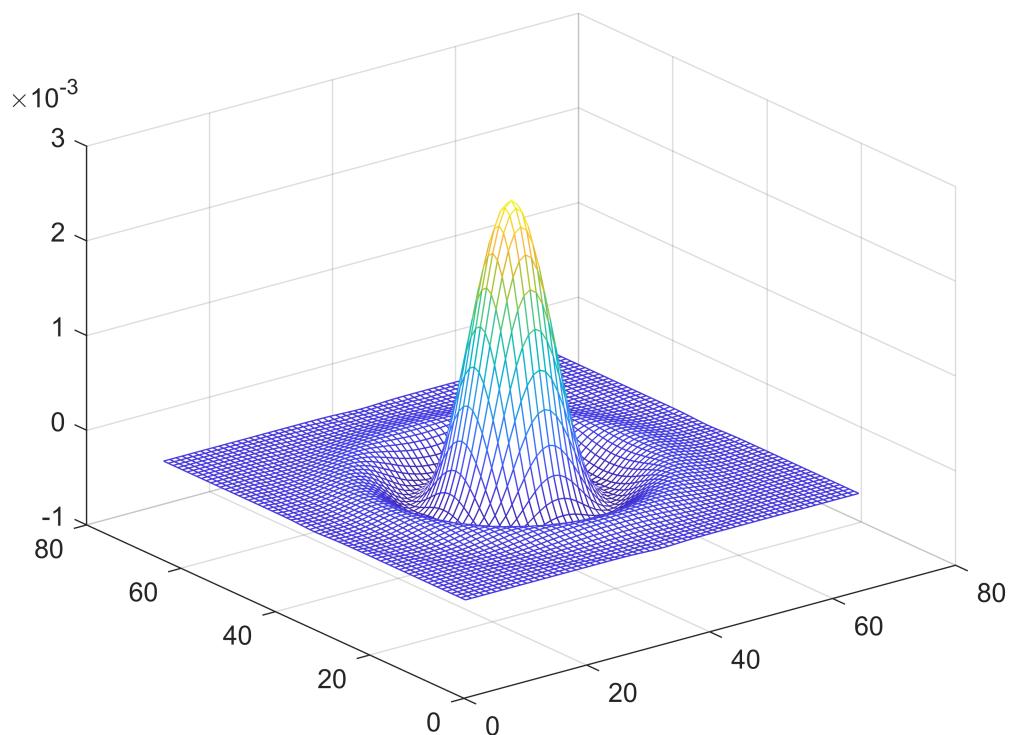
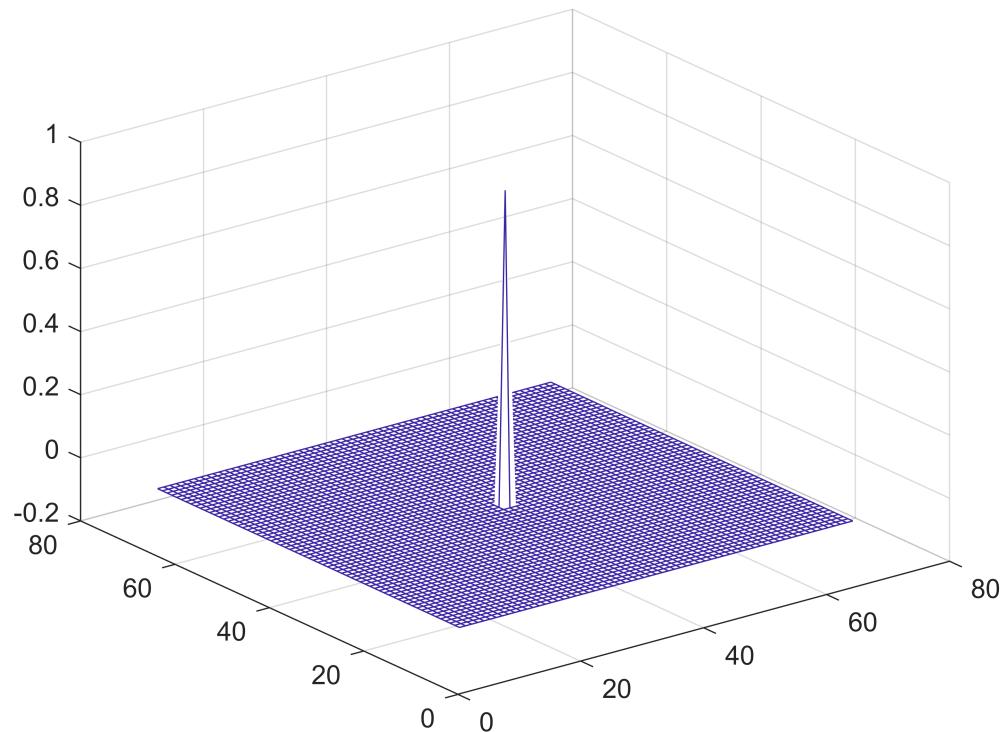


Now use this to lowpassfilter the image: The plots above can be generated in similar fashion.

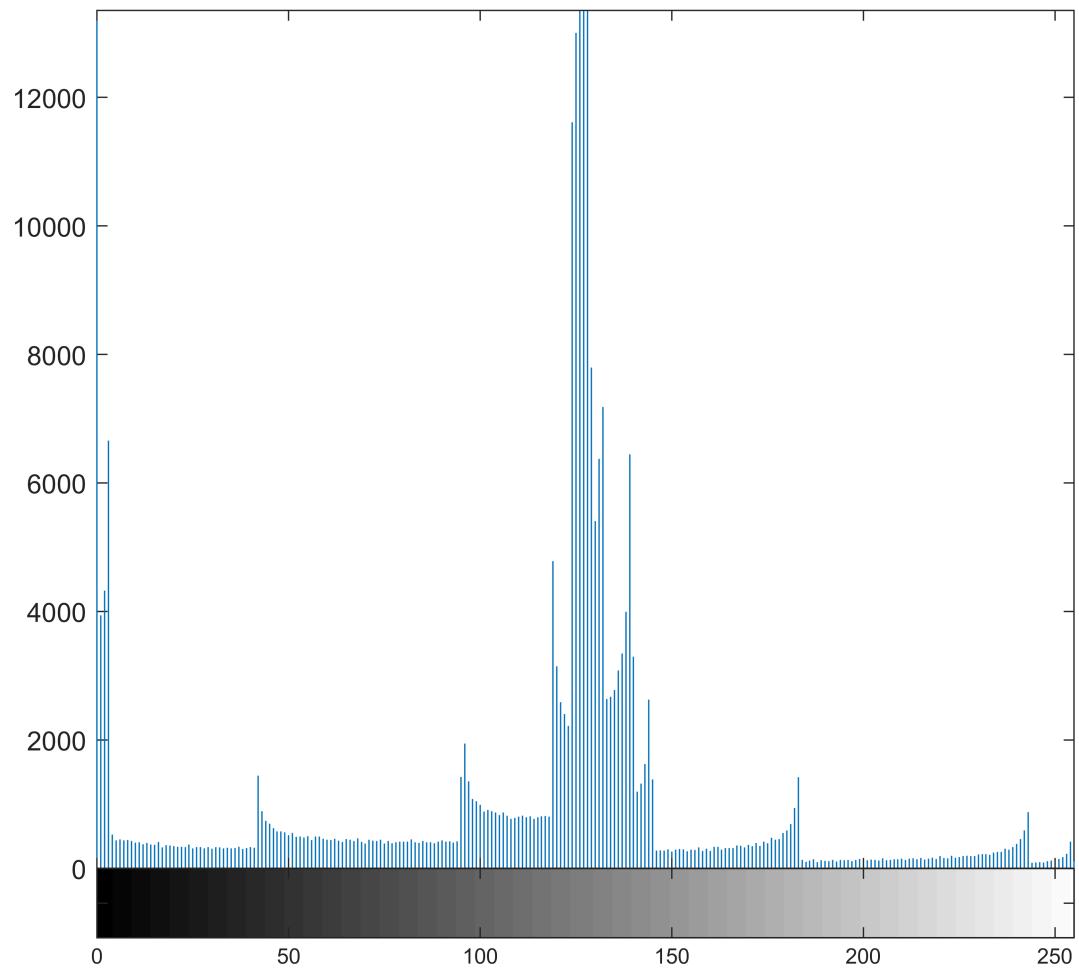
```
zplate_LP1 = imfilter(zplate, LP1_2D, 'replicate');
imshow(zplate_LP1,[])
```





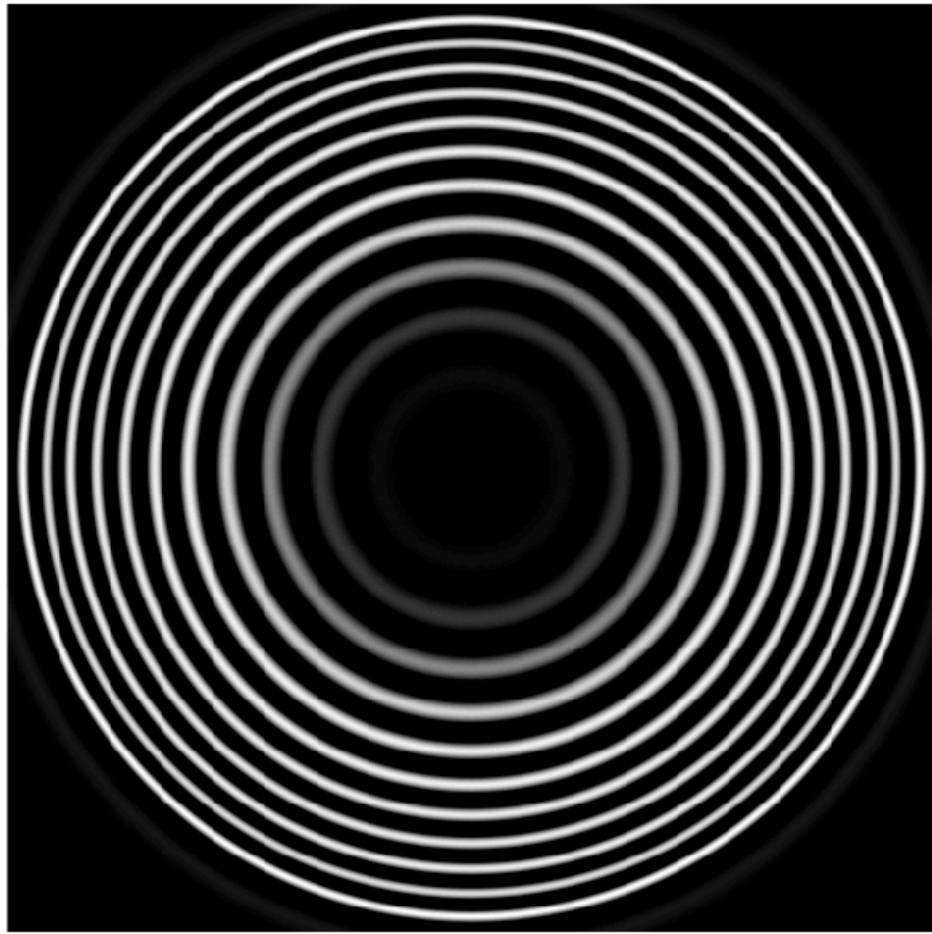


```
imhist(zplate_LP1)
```

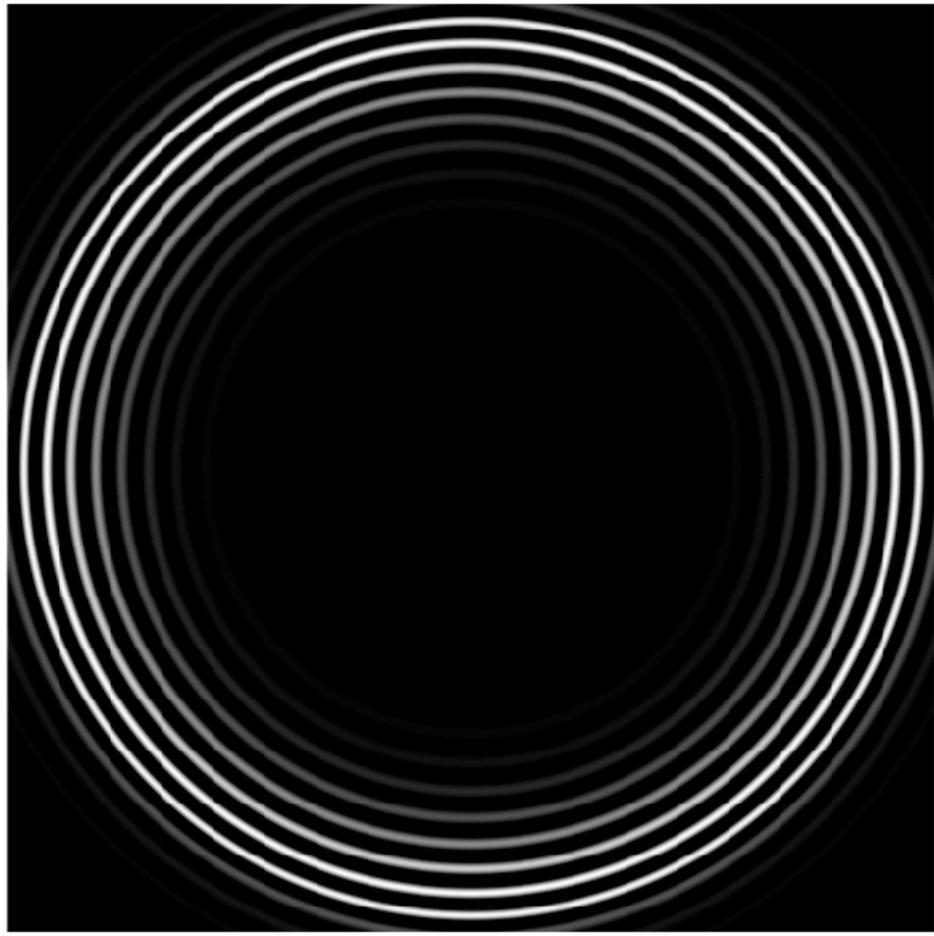


High pass

```
zplate_HP1 = imfilter(zplate, HP1_2D, 'replicate');  
imshow(zplate_HP1,[])
```

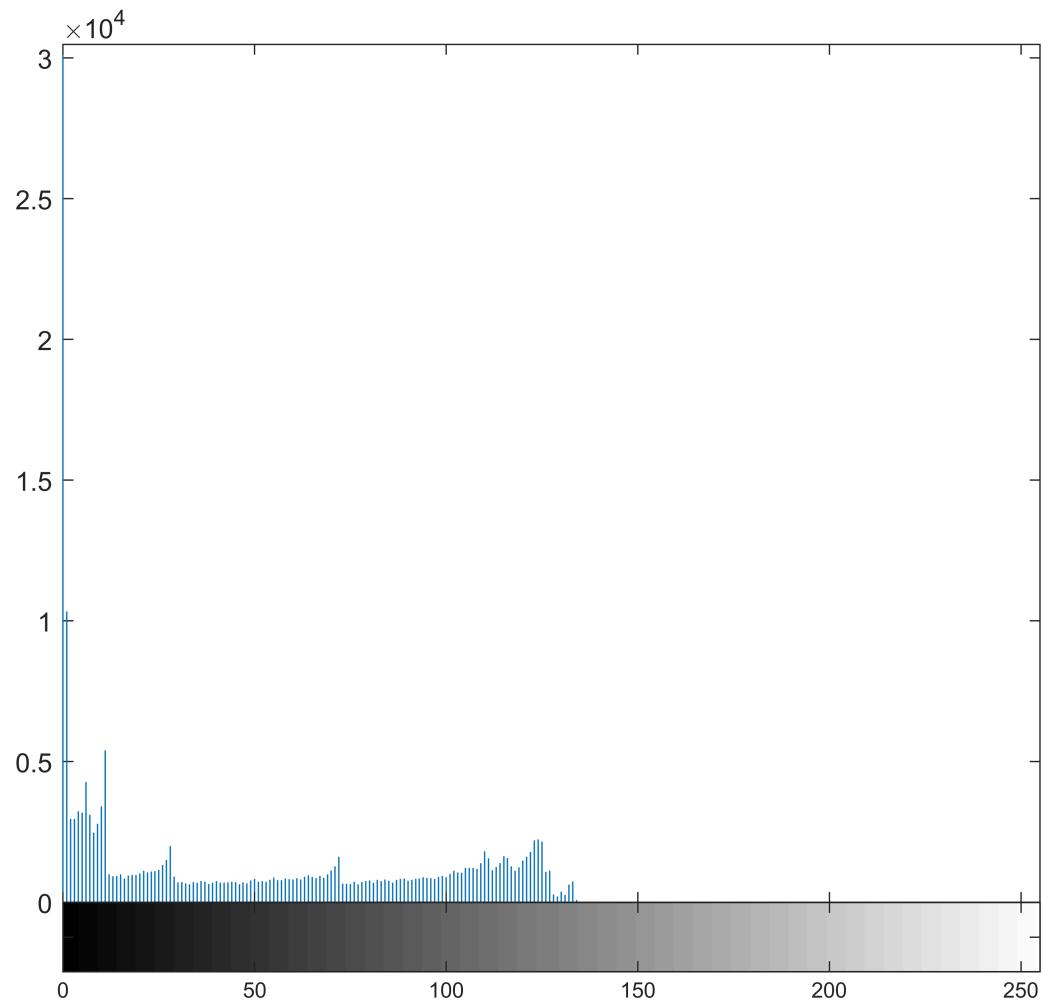


```
zplate_HP2 = imfilter(zplate, HP2_2D, 'replicate');  
imshow(zplate_HP2, [])
```

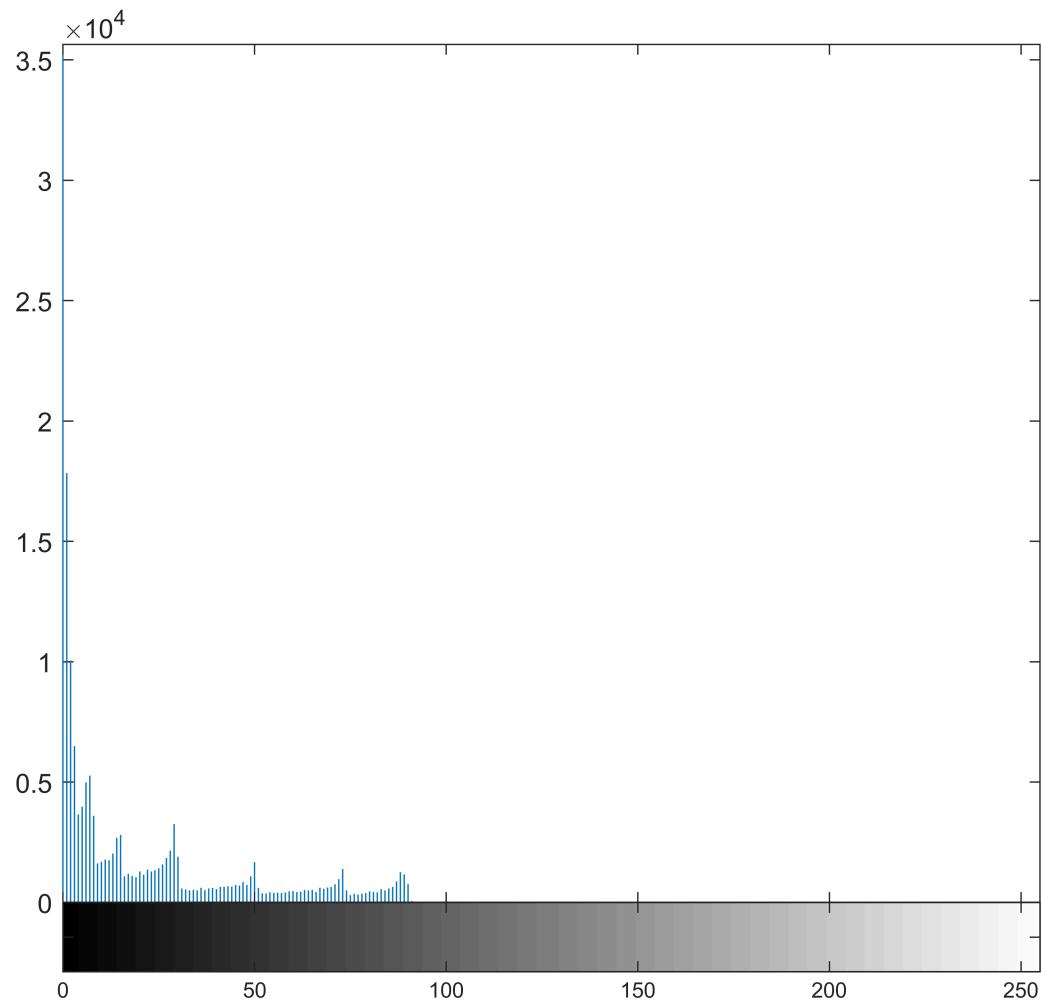


Histogram

```
imhist(zplate_HP1)
```

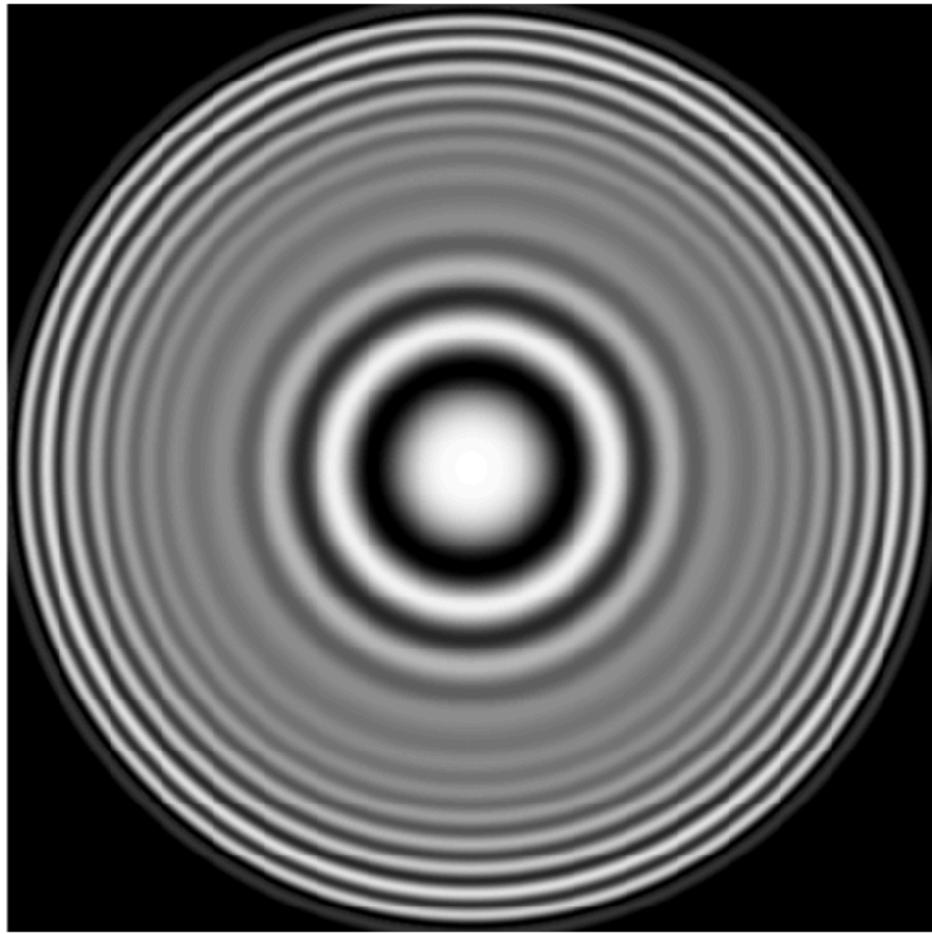


```
imhist(zplate_HP2)
```



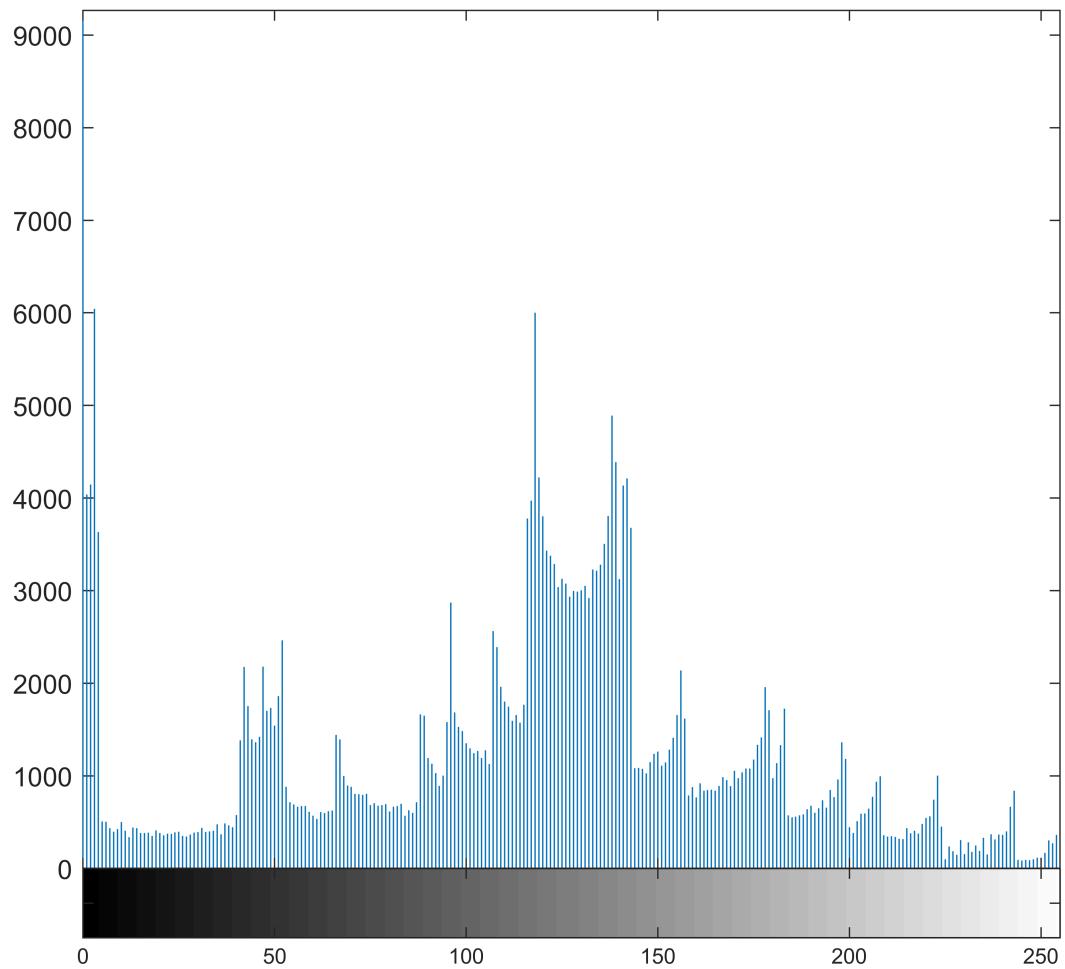
Band-reject

```
zplate_BR3 = imfilter(zplate, BR1_2D, 'replicate');  
imshow(zplate_BR3,[])
```



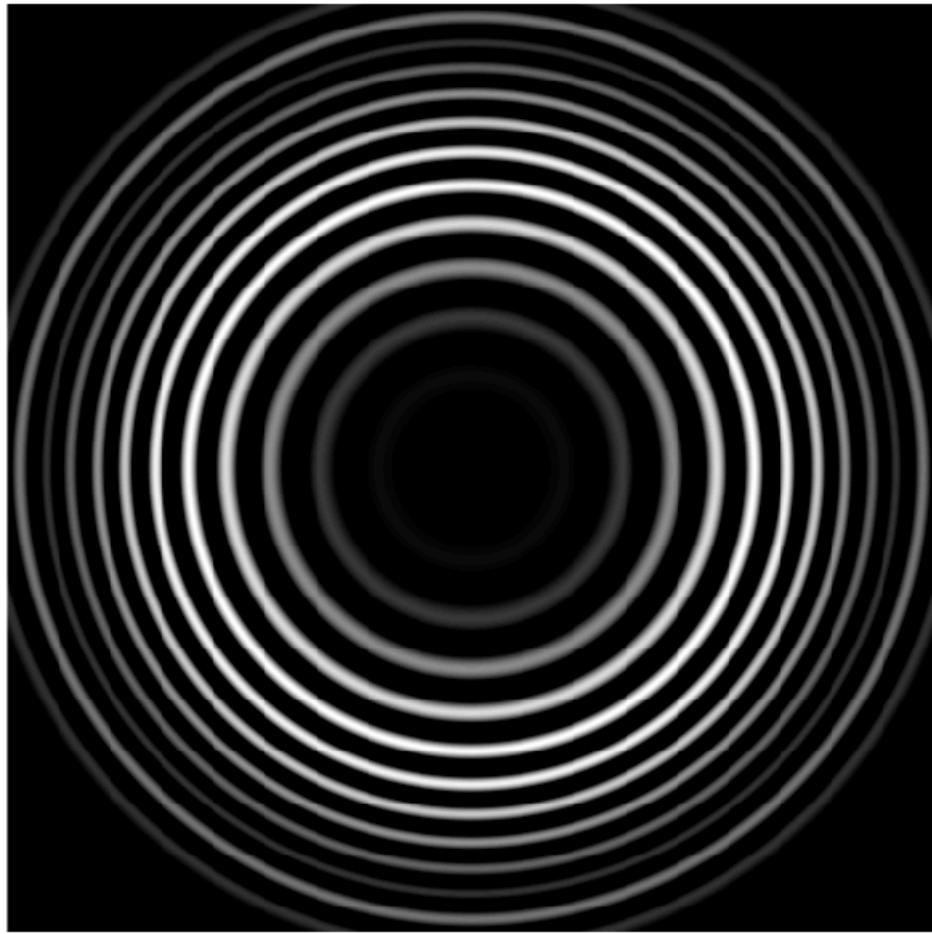
Histogram

```
imhist(zplate_BR3)
```



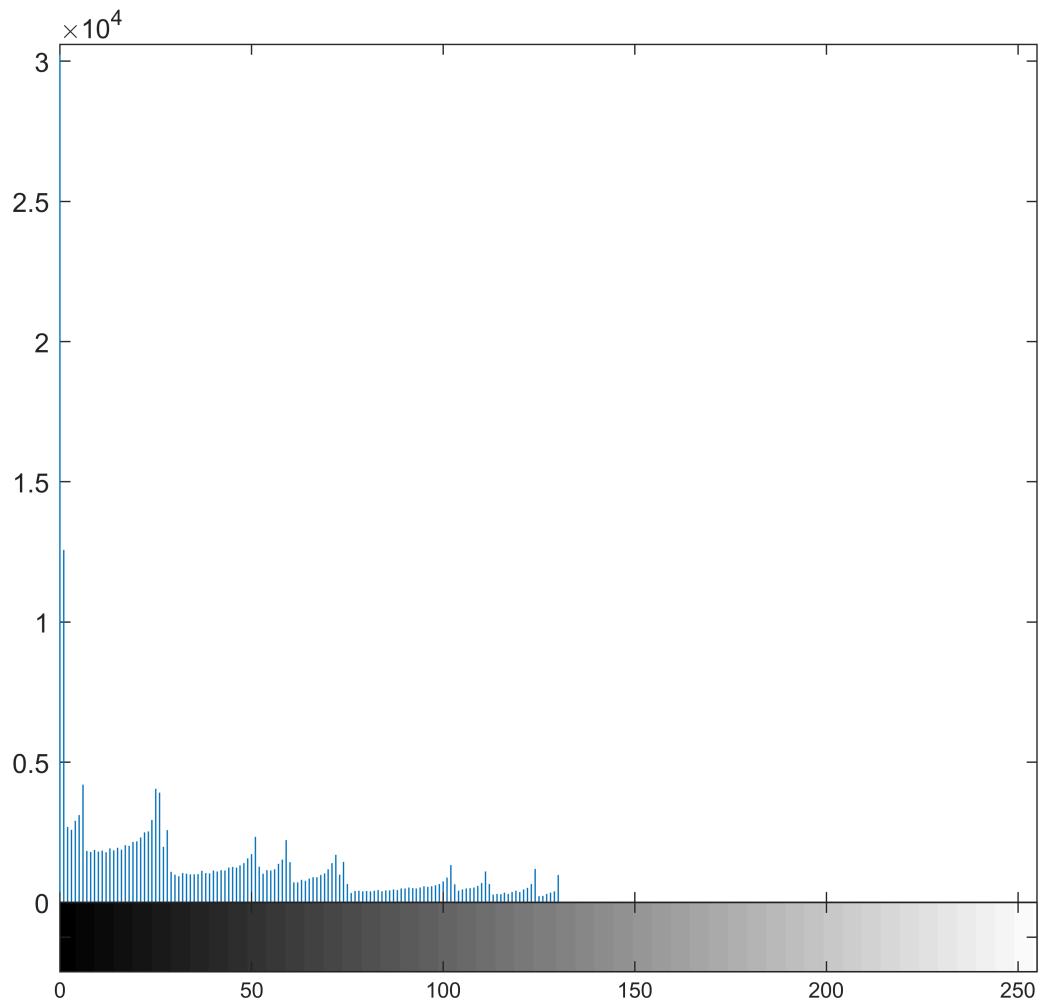
Band Pass

```
zplate_BP = imfilter(zplate, BP_2D, 'replicate');
imshow(zplate_BP, [])
```



Histogram

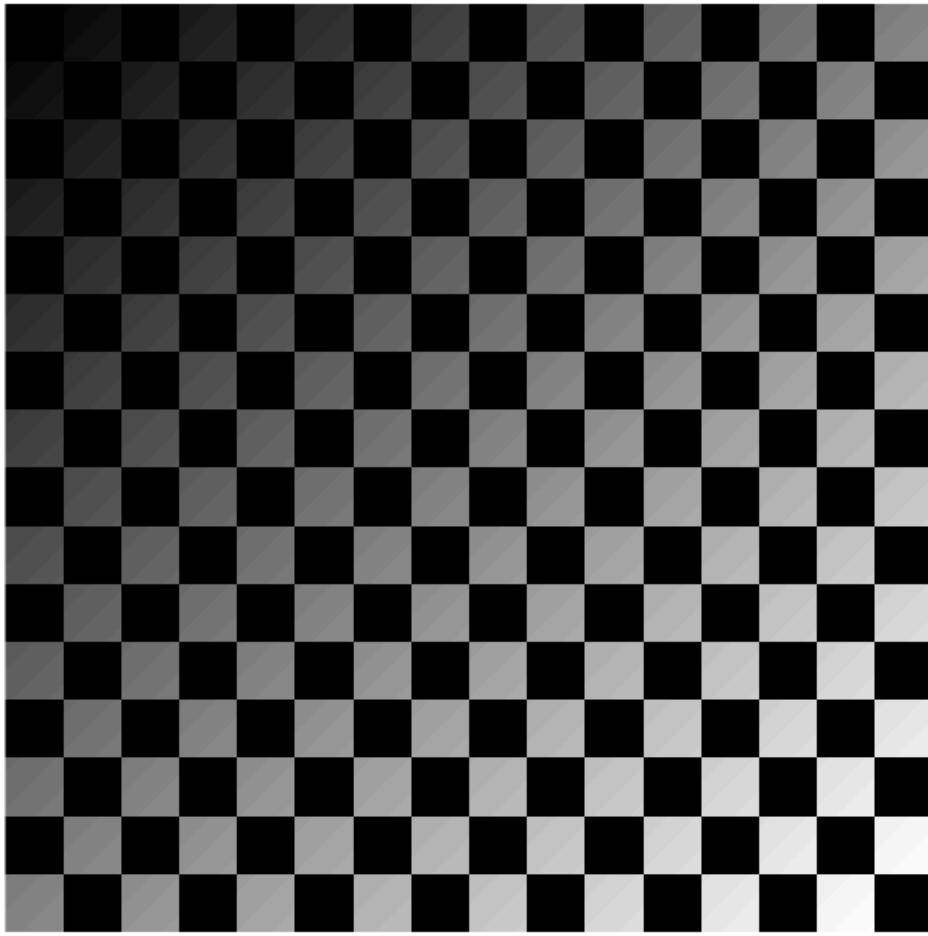
```
imhist(zplate_BP)
```



Plot the filters generated in 5. Apply the three filters generated to the zoneplate image, plot the results, and plot the histogram of the results.

Low pass filtering can be used to compensate for uneven illumination. For example, the following checkerboard image has different shading, showing that the illumination is not consistent. This code reads in the image, converts to double, then rescales the image to the range [0,1], to make computations take place in the same range.

```
cb_shaded=im2double(imread("checkerboard1024-shaded.tif"));
cb_shaded=rescale(cb_shaded,0,1);
imshow(cb_shaded,[]);
```



7a. Use a Gaussian filter to blur this image. The result should be a consistent image that varies in intensity smoothly, with no evidence of the individual squares. Use the `imgaussfilt` function to perform the blurring operation and experiment with the value of sigma until the result is a smooth image.

Use the `imshow` command, with the `[]` option, to display your result and save the result in a variable.

7.b. Now divide the original image by the the result in 7a. Use the "elementwise" division, which in MATLAB is the `./` command

Plot the results with the `imshow` command. It will be useful to use the `[]` option in `imshow` to scale the output.

Comment on the output. With a correct amount of blur, the result should be a checkerboard pattern that does not have the shading strongly shown. Does the result show a perfectly even checkerboard? Explain using the intensity level from 7a, is that completely smooth or does some variation exist? Why?