

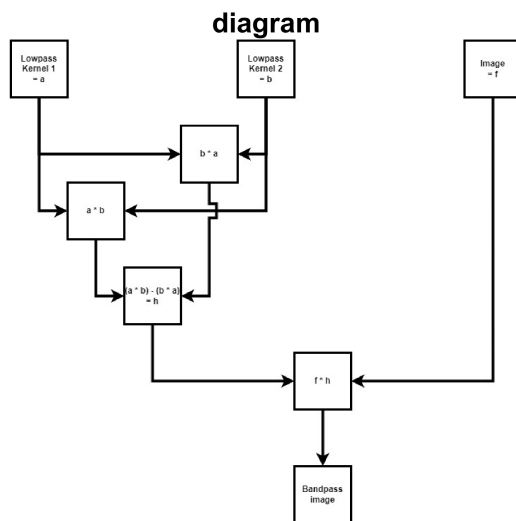
Question 1:

a.

To construct a bandpass filter in the image domain using only lowpass filters, you can create two lowpass filter kernels and convolve them together each way and subtracting the two and finally convolving the new kernel with the input image.

b.

```
imshow(imread("diagram.jpg"));  
title('diagram')
```



c.

Input image $f(x, y)$, lowpass kernel 1 $h_1(x, y)$, lowpass kernel 2 $h_2(x, y)$, Output image $g(x, y)$.

$$h_{12}(x, y) = h_1(x, y) * h_2(x, y), h_{21}(x, y) = h_2(x, y) * h_1(x, y)$$

$$h(x, y) = h_{12}(x, y) - h_{21}(x, y)$$

$$g(x, y) = f(x, y) * h(x, y)$$

d.

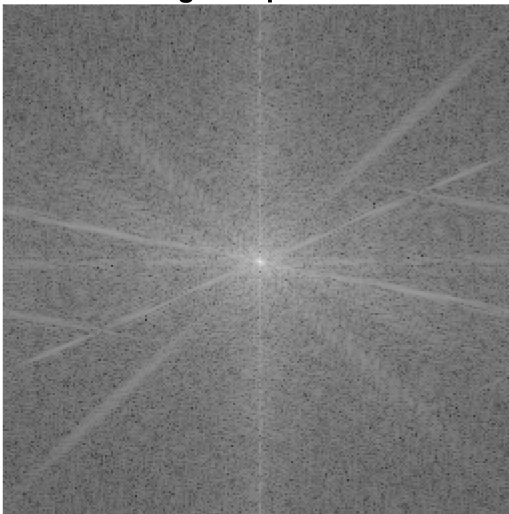
```
% original image  
f_in = (imread("mycameraman2.png"));  
imshow(f_in)  
title('original image')
```

original image



```
F_in = fftshift(fft2(f_in));  
magnitude = abs(F_in);  
mag_scaled = uint8(15 * log(1 + magnitude));  
imshow(mag_scaled);  
title('original spectrum')
```

original spectrum



```
% normal lowpass a  
lowpass1 = fspecial('average', 3)
```

```
lowpass1 = 3x3
0.1111    0.1111    0.1111
0.1111    0.1111    0.1111
0.1111    0.1111    0.1111
```

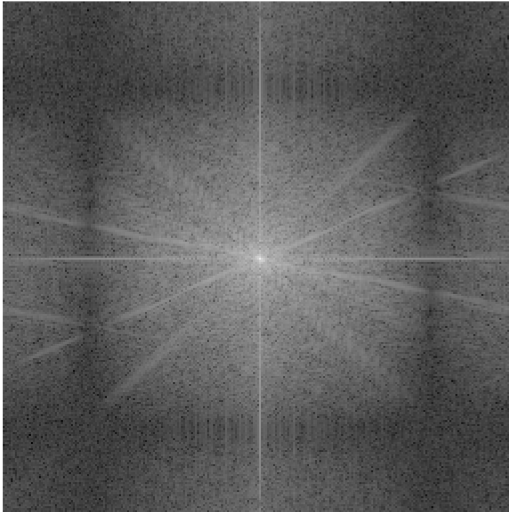
```
a = imfilter(f_in, lowpass1, 'conv');
imshow(a);
title('normal 3x3 average')
```

normal 3x3 average



```
A = fftshift(fft2(a));
magnitude = abs(A);
mag_scaled = uint8(15 * log(1 + magnitude));
imshow(mag_scaled);
title('3x3 spectrum')
```

3x3 spectrum



```
% normal lowpass b  
lowpass2 = fspecial('average', 9)
```

```
lowpass2 = 9x9  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123 ...  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123  
    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
```

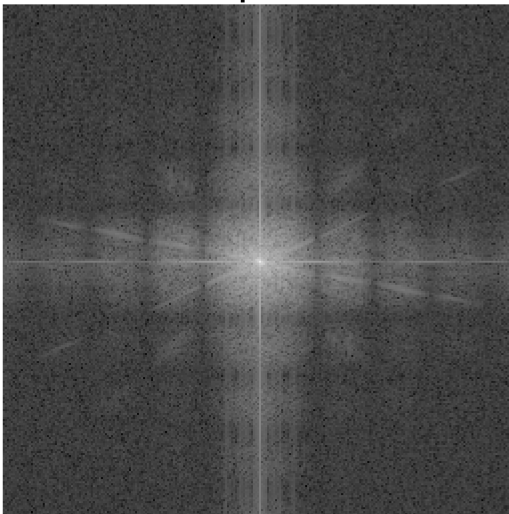
```
b = imfilter(f_in, lowpass2, 'conv');  
imshow(b);  
title('normal 3x3 average')
```

normal 3x3 average



```
B = fftshift(fft2(b));  
magnitude = abs(B);  
mag_scaled = uint8(15 * log(1 + magnitude));  
imshow(mag_scaled);  
title('9x9 spectrum')
```

9x9 spectrum



```
% a * b  
ab = imfilter(lowpass1, lowpass2, 'conv')
```

```
ab = 3×3
    0.0123    0.0123    0.0123
    0.0123    0.0123    0.0123
    0.0123    0.0123    0.0123
```

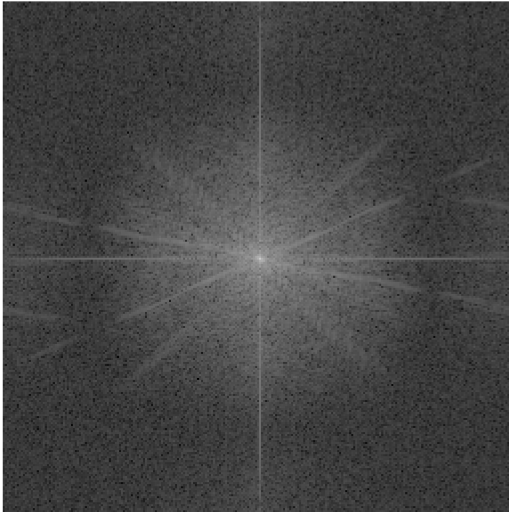
```
f_ab = imfilter(f_in, ab, 'conv');
imshow(f_ab * 10);
title('attempt 1 image (scaled)')
```

attempt 1 image (scaled)



```
A = fftshift(fft2(f_ab));
magnitude = abs(A);
mag_scaled = uint8(15 * log(1 + magnitude));
imshow(mag_scaled);
title('attempt 1 spectrum')
```

attempt 1 spectrum



```
% b * a
ba = imfilter(lowpass2, lowpass1, 'conv')
```

```
ba = 9x9
    0.0055    0.0082    0.0082    0.0082    0.0082    0.0082    0.0082    0.0082 ...
    0.0082    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
    0.0082    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
    0.0082    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
    0.0082    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
    0.0082    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
    0.0082    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
    0.0082    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123    0.0123
    0.0055    0.0082    0.0082    0.0082    0.0082    0.0082    0.0082    0.0082
```

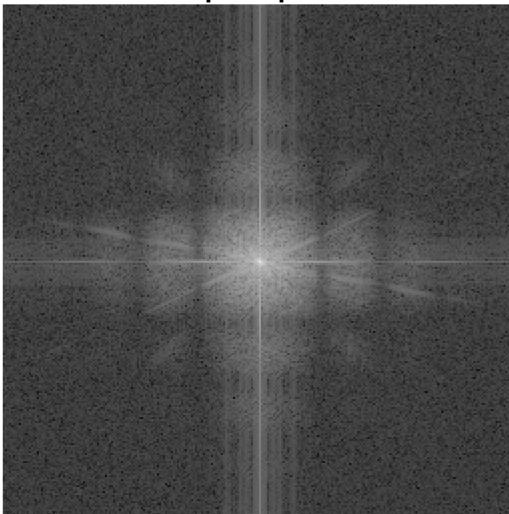
```
f_ba = imfilter(f_in, ba, 'conv');
imshow(f_ba);
title('attempt 2 image')
```

attempt 2 image



```
B = fftshift(fft2(f_ba));  
magnitude = abs(B);  
mag_scaled = uint8(15 * log(1 + magnitude));  
imshow(mag_scaled);  
title('attempt 2 spectrum')
```

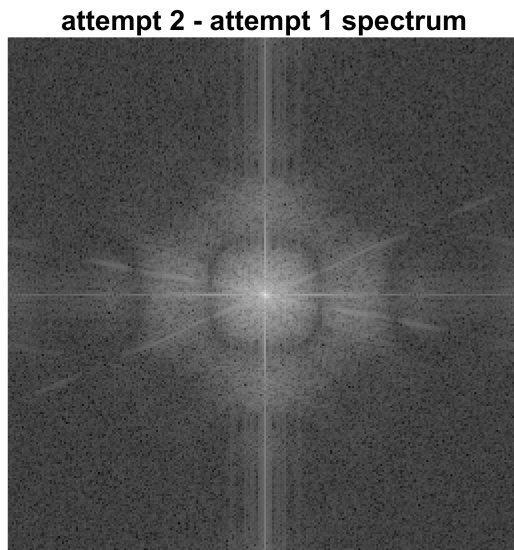
attempt 2 spectrum



```
% filtered subtraction  
bp = abs(f_ba - f_ab);  
BP = fftshift(fft2(bp));
```

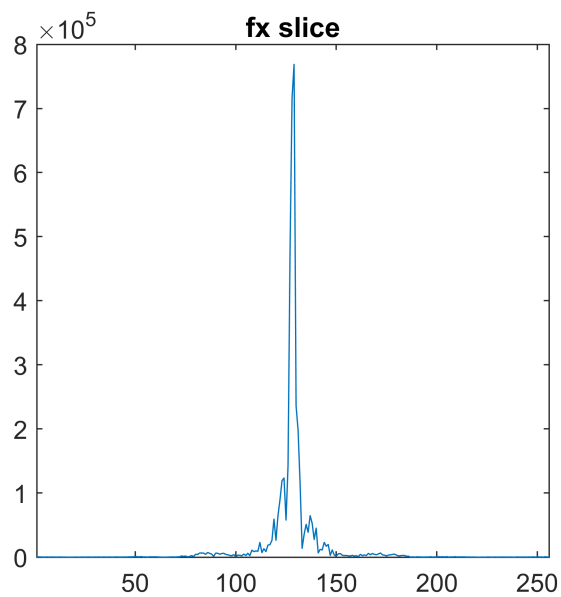


```
magnitude = abs(BP);  
mag_scaled = uint8(15 * log(1 + magnitude));  
imshow(mag_scaled);  
title('attempt 2 - attempt 1 spectrum')
```

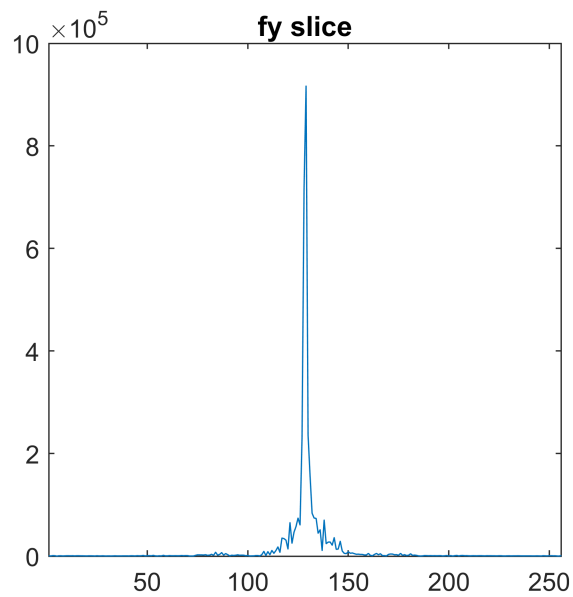


e.

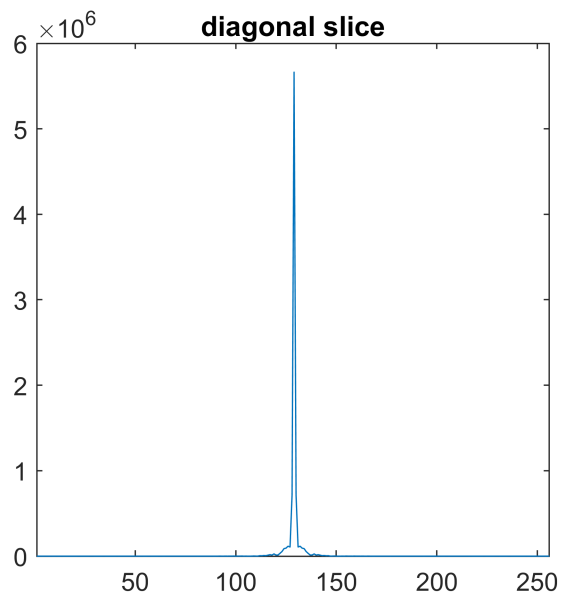
```
plot(magnitude(128, :));  
title('fx slice')  
xlim([1 256])
```



```
plot(magnitude(:, 128));  
title('fy slice')  
xlim([1 256])
```



```
diagonal_slice = zeros(1, min(size(magnitude)));  
for i = 1:min(size(magnitude))  
    diagonal_slice(i) = magnitude(i, i);  
end  
plot(real(diagonal_slice));  
title('diagonal slice')  
xlim([1 256])
```



Most of the image has low spatial frequency so a large spike will be seen in the center.

f.

I was not able to successfully construct a bandpass filter to eliminate the low frequency data.