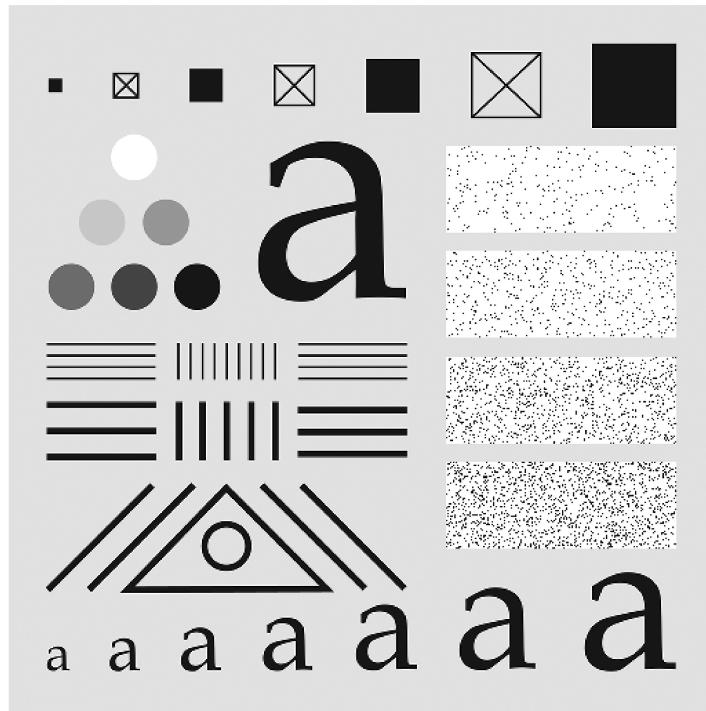


```
%%Q1%%
%a%
img=imread('testpattern512.tif');
imshow(img)
```



```
[M,N]=size(img)
```

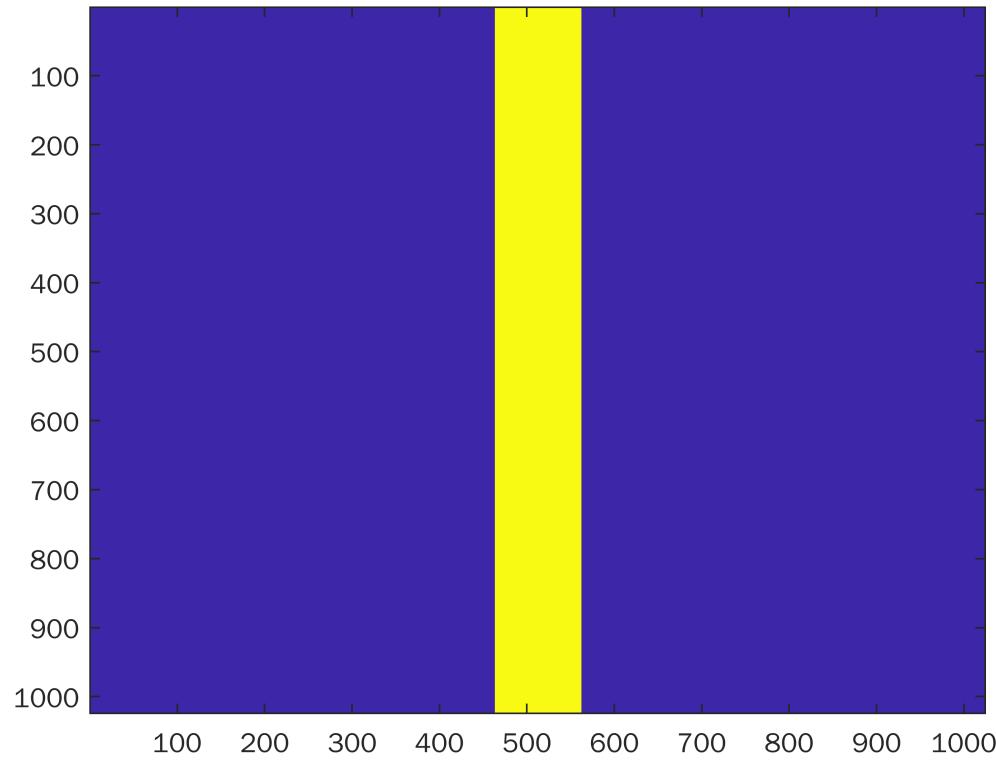
```
M = 512
N = 512
```

```
image_FD=fft2(img,2*M,2*N)
```

```
image_FD = 1024x1024 complex
107 ×
 5.3584 + 0.0000i -0.0578 - 3.3634i 0.1102 + 0.1245i 0.1480 - 1.2315i ...
 0.0204 - 3.4275i -2.1123 + 0.0877i 0.1503 - 0.1099i -0.7856 - 0.1462i
 -0.0588 - 0.0196i 0.1542 + 0.0080i -0.0493 - 0.1866i -0.0909 + 0.0379i
 -0.0102 - 1.0582i -0.6297 - 0.1244i -0.1426 - 0.0438i -0.2325 + 0.0374i
 0.0130 + 0.0006i 0.0060 - 0.0880i -0.1034 + 0.0089i 0.0004 + 0.0453i
 -0.0273 - 0.5970i -0.4328 - 0.0880i -0.1039 + 0.0938i -0.0517 + 0.0373i
 0.0614 + 0.0622i -0.0353 - 0.0323i 0.0435 + 0.0985i 0.0697 - 0.0757i
 0.0463 - 0.3867i -0.2558 - 0.0473i 0.0146 - 0.0025i -0.0991 - 0.0648i
 0.1971 + 0.0341i -0.0220 - 0.1252i 0.0111 + 0.0274i -0.0211 - 0.0654i
 0.0979 - 0.4706i -0.3030 - 0.0840i -0.0195 - 0.0108i -0.1289 - 0.0151i
  :
 :
```

```
[U,V]=meshgrid(-M:1:M-1,-N:1:N-1);
Uc=50; Vc=512;
```

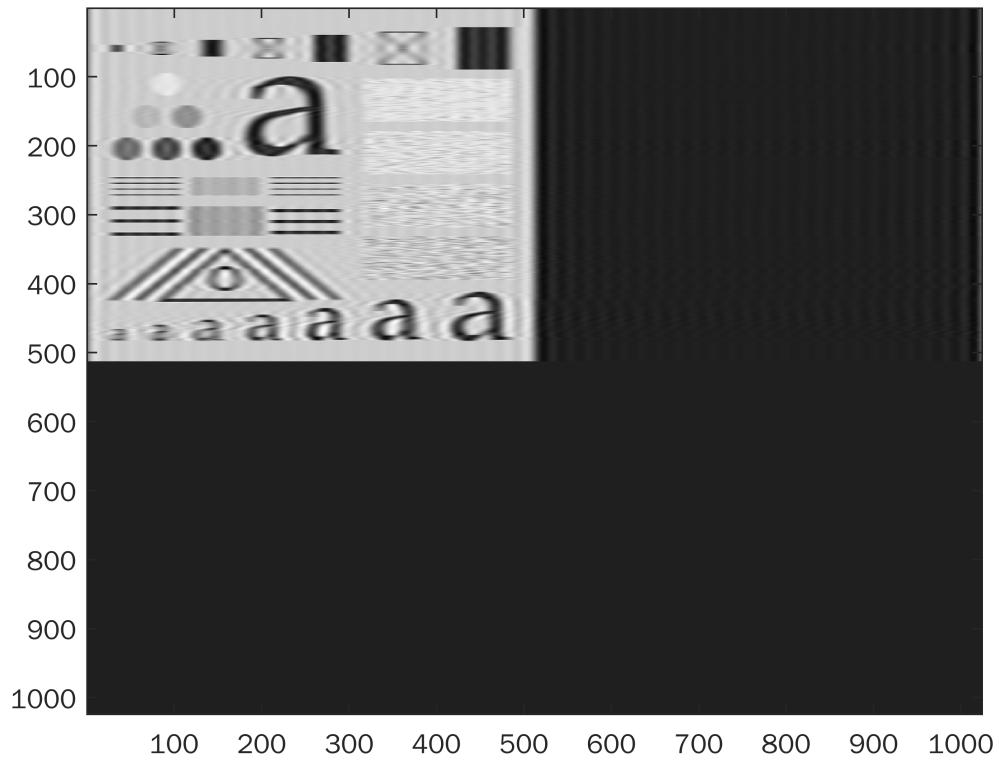
```
U2= U>-Uc & U<Uc;  
V2= V>-Vc & V<Vc ;  
  
Ideal=U2.*V2;  
figure; imagesc(Ideal);
```



```
Ideal=ifftshift(Ideal);  
figure; imagesc(Ideal);axis off
```



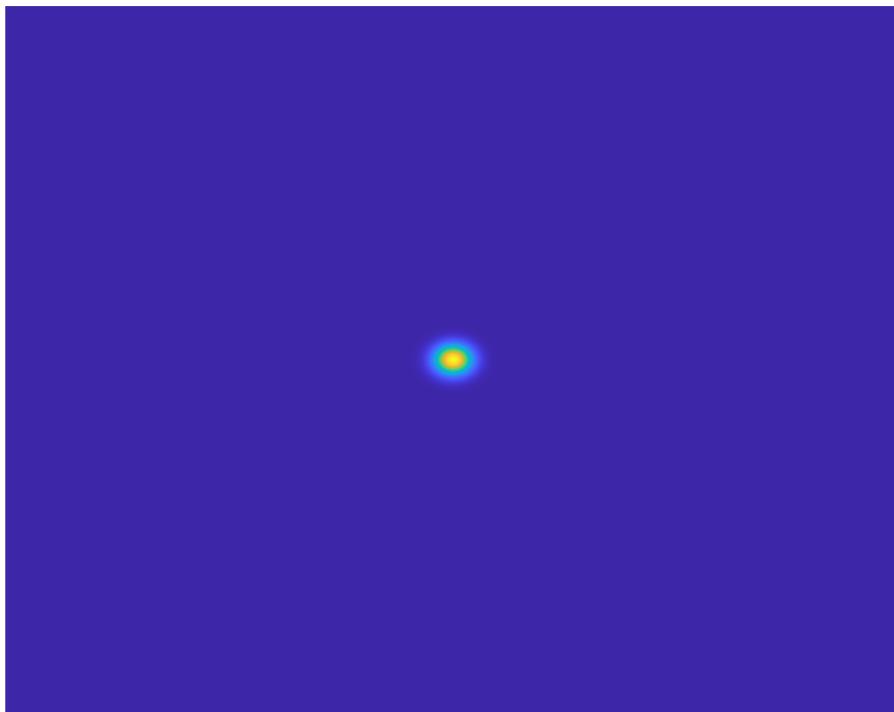
```
Image_New1=ifft2((Ideal.*image_FD));  
figure;imagesc(real(Image_New1)),colormap(gray);
```



```
img_transformed=Image_New1(1:M,1:N);
figure;imshow(img_transformed,[ ]);
```



```
%b%
fc=15;
Gau_F=exp(-(U.^2+V.^2)/2/fc^2);
figure; imagesc(Gau_F);axis off
```



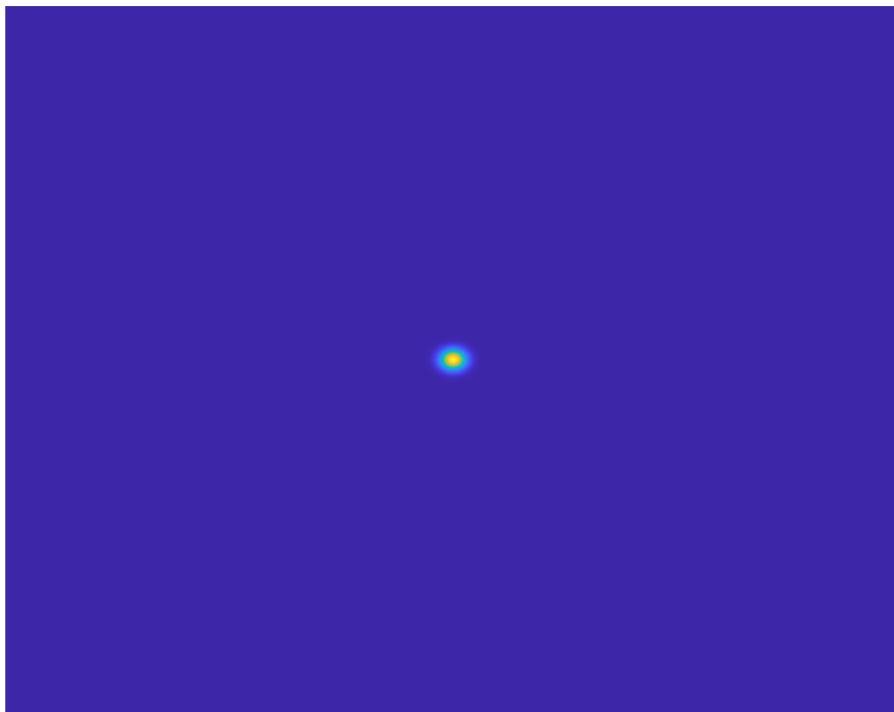
```
Gau_F2=ifftshift(Gau_F);
Image_R=ifft2(Gau_F2.*image_FD);

Image_R_15=Image_R(1:M, 1:N);
figure; imshow(Image_R_15,[]);title ([ 'filtered image with cutoff frequency ',num2str(
```

filtered image with cutoff frequency 15



```
%----fc=10----%
fc=10;
Gau_F=exp(-(U.^2+V.^2)/2/fc^2);
figure; imagesc(Gau_F);axis off
```



```
Gau_F2=ifftshift(Gau_F);
Image_R=ifft2(Gau_F2.*image_FD);

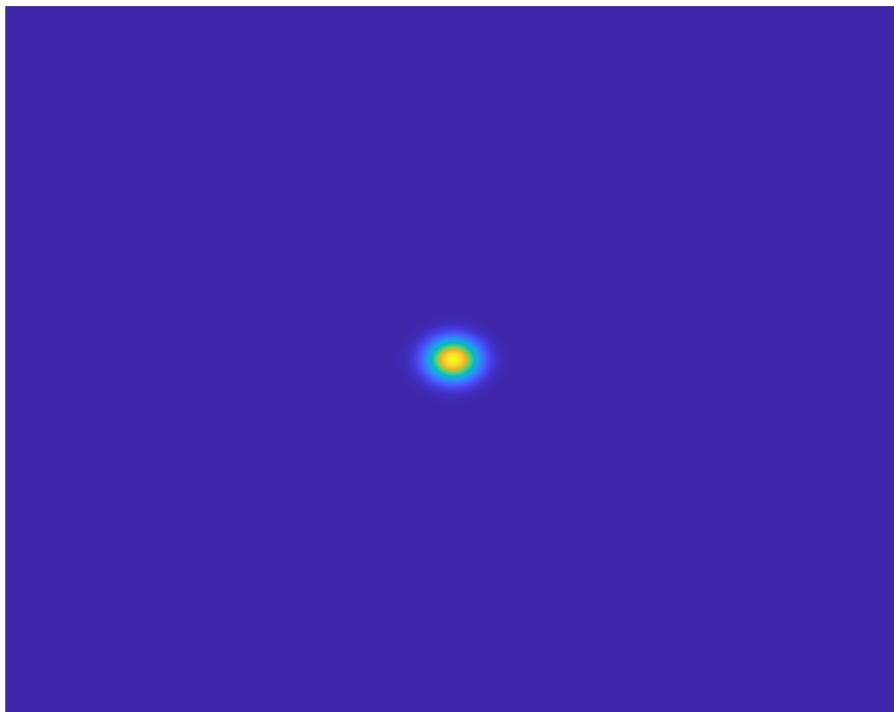
Image_R_10=Image_R(1:M, 1:N);
figure; imshow(Image_R_10,[]);title ([ 'filtered image with cutoff frequency ',num2str(
```

filtered image with cutoff frequency 10



```
%----fc=20----%
```

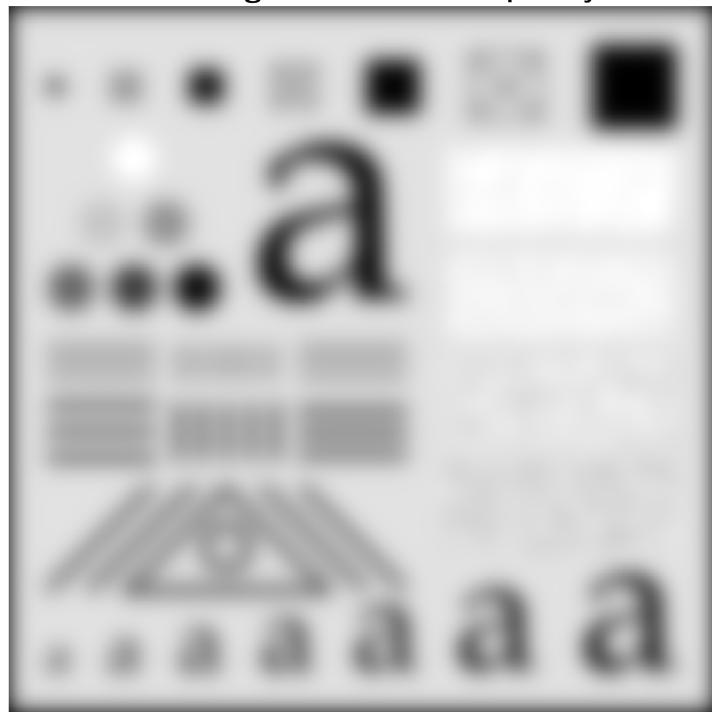
```
fc=20;  
Gau_F=exp(-(U.^2+V.^2)/2/fc^2);  
figure; imagesc(Gau_F);axis off
```



```
Gau_F2=ifftshift(Gau_F);
Image_R=ifft2(Gau_F2.*image_FD);

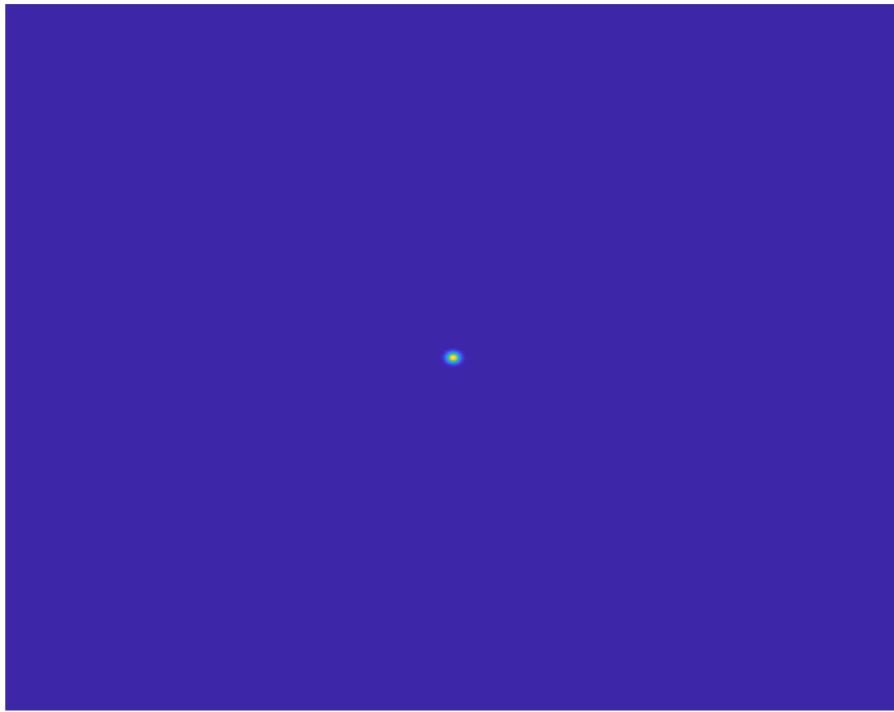
Image_R_20=Image_R(1:M, 1:N);
figure; imshow(Image_R_20,[]);title ([ 'filtered image with cutoff frequency ',num2str(
```

filtered image with cutoff frequency 20



```
%----fc=5----%
```

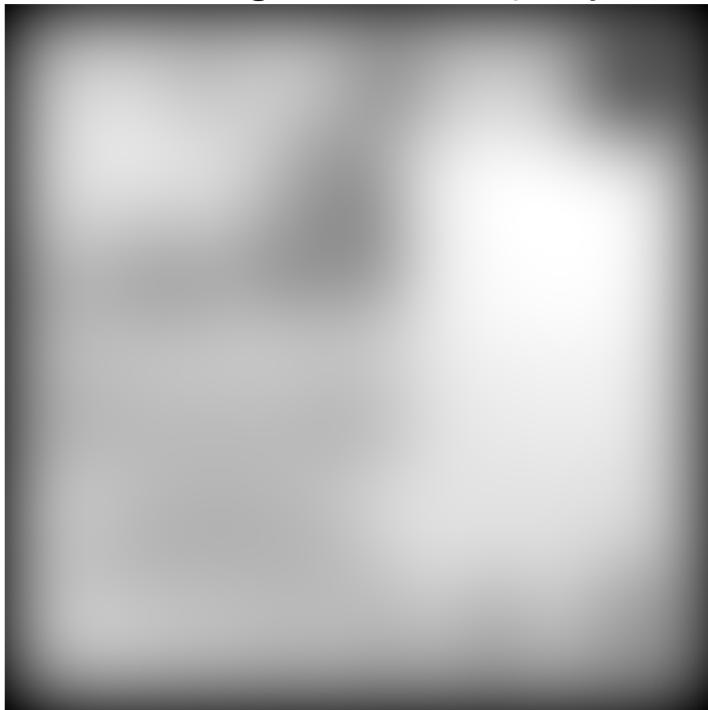
```
fc=5;  
Gau_F=exp(-(U.^2+V.^2)/2/fc^2);  
figure; imagesc(Gau_F);axis off
```



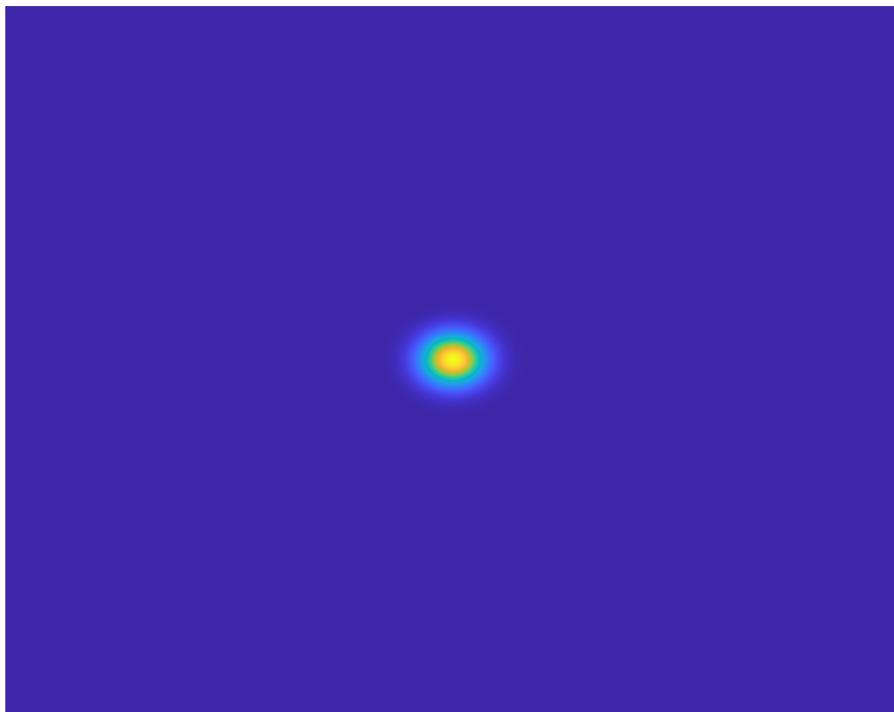
```
Gau_F2=ifftshift(Gau_F);
Image_R=ifft2(Gau_F2.*image_FD);

Image_R_5=Image_R(1:M, 1:N);
figure; imshow(Image_R_5,[]);title (['filtered image with cutoff frequency ',num2str( f
```

filtered image with cutoff frequency 5



```
%----fc=25----%
fc=25;
Gau_F=exp(-(U.^2+V.^2)/2/fc^2);
figure; imagesc(Gau_F);axis off
```



```
Gau_F2=ifftshift(Gau_F);
Image_R=ifft2(Gau_F2.*image_FD);

Image_R_25=Image_R(1:M, 1:N);
figure; imshow(Image_R_25,[]);title ([ 'filtered image with cutoff frequency ',num2str(
```

filtered image with cutoff frequency 25



```
%-----MSE-----%  
img=double(img)
```

```
img = 512x512
  225 225 225 225 225 225 225 225 225 225 225 225 225 225 225 225 ...
  225 225 224 225 224 225 225 225 225 224 225 224 225 225 225 225
  225 224 225 225 225 225 225 225 225 225 224 225 225 225 225 225
  224 225 224 225 225 225 224 224 225 225 225 225 225 225 225 225
  225 225 225 225 224 224 225 225 225 225 225 225 225 225 225 225
  225 225 225 225 225 224 224 225 225 225 225 225 225 225 225 225
  225 225 225 225 224 224 224 225 225 225 225 225 225 225 225 224
  225 225 225 224 224 225 225 224 224 224 224 224 225 225 225 225
  224 225 225 225 224 224 224 225 225 225 225 225 225 225 224 225
  225 224 224 225 224 225 225 225 225 225 224 225 225 225 225 224
  225 225 225 224 224 225 225 224 225 225 225 224 225 225 225 225
  .
  .
```

```
MSE_gau_15 = round(immse(Image_R_15,img))
```

MSE gau 15 = 3564

```
MSE qua 5 = round(immse(Image R 5,img))
```

MSE\_gau\_5 = 5773

```
MSE_gau_25 = round(immse(Image_R_25,img))
```

MSE gau 25 = 2833

```
MSE_gau_10 = round(immse(Timage_B_10,img))
```

```

MSE_gau_10 = 4297
MSE_gau_20 = round(immse(Image_R_20,img))
MSE_gau_20 = 3140

MSEs =[MSE_gau_15, MSE_gau_5, MSE_gau_25, MSE_gau_10,MSE_gau_20]

MSEs = 1x5
    3564      5773      2833      4297      3140

sorted_MSEs=sort(MSEs, "ascend")

sorted_MSEs = 1x5
    2833      3140      3564      4297      5773

table(sorted_MSEs)

ans = 1x1 table

```

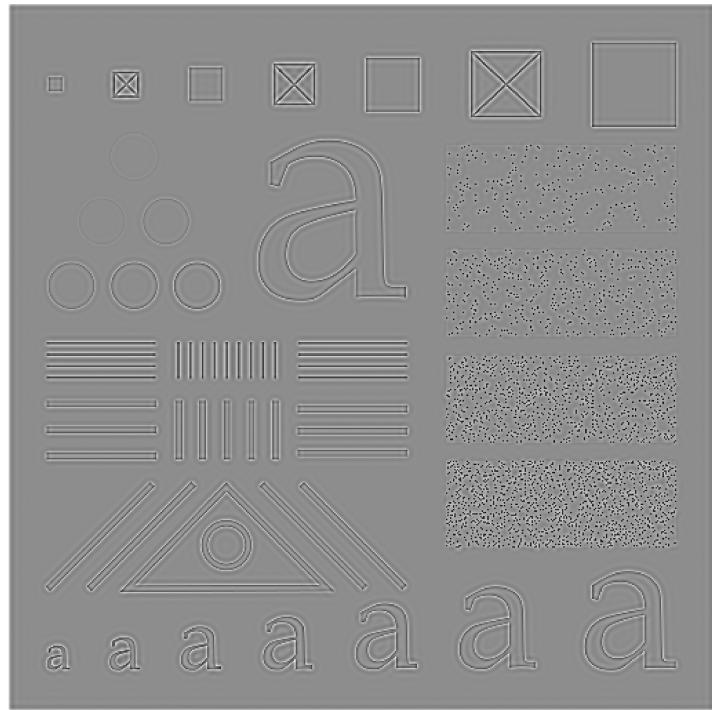
	sorted_MSEs				
1	2833	3140	3564	4297	5773

%Comment: Since the amount of information increase with more level of frequencies are kept when cutoff point increase, MSE decreases. If we think about the structure of lowpass filter, the only inside area is preserved from origin to cutoff frequency level, outside is set to zero, it seems to be consistent that filtered image is closer the the original one and error rate decrease when cutoff level increases. Cutoff point is a kind of sigma. When cutoff point increase, the sigma will increase and so the area of which is kept will increase also. So, MSE will decrease.

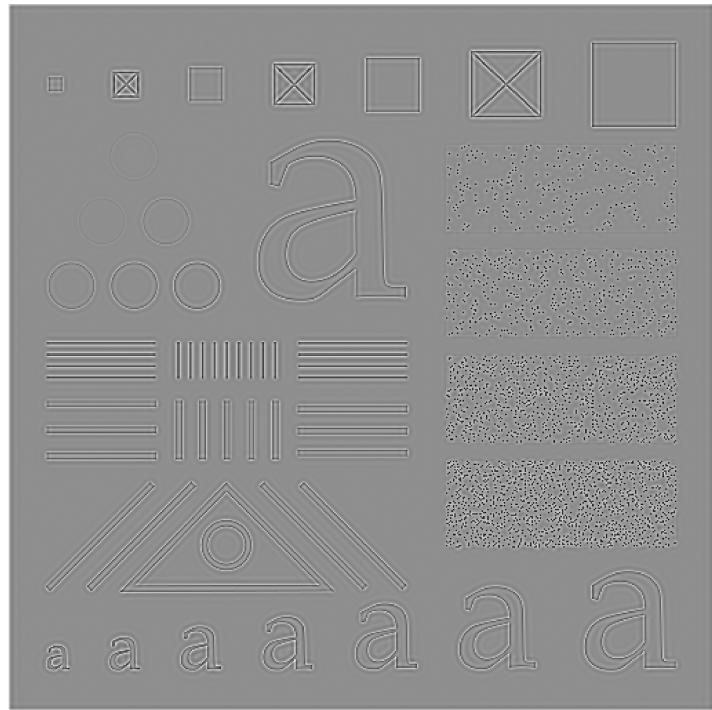
```

%C%
fc=180;
order=5; D=sqrt(U.^2+V.^2);
% high pass
    BW_HPF=1./(1+(fc./D).^(2*order));
BW_HPF=ifftshift(BW_HPF);
Image_R=ifft2(BW_HPF.*image_FD);
Image_R2_180=Image_R(1:M, 1:N);
figure; imshow((Image_R2_180),[]);

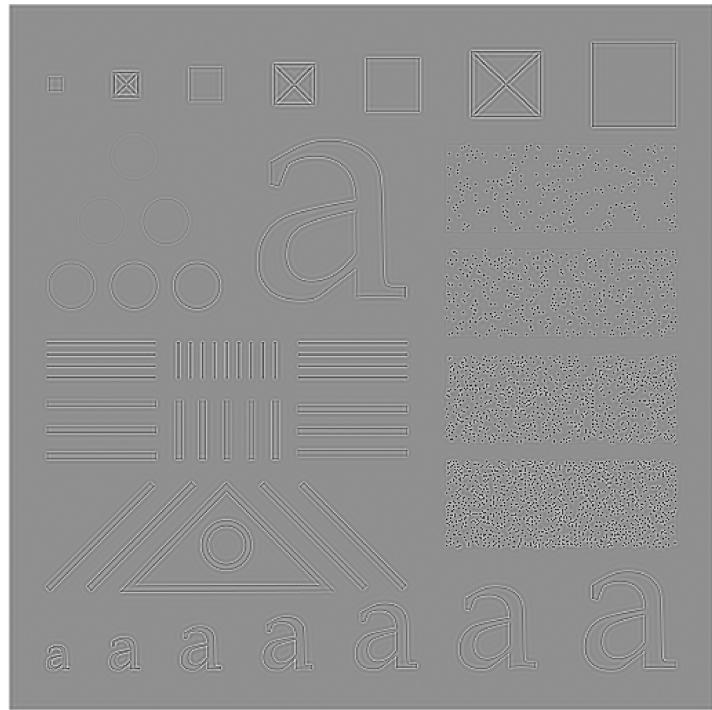
```



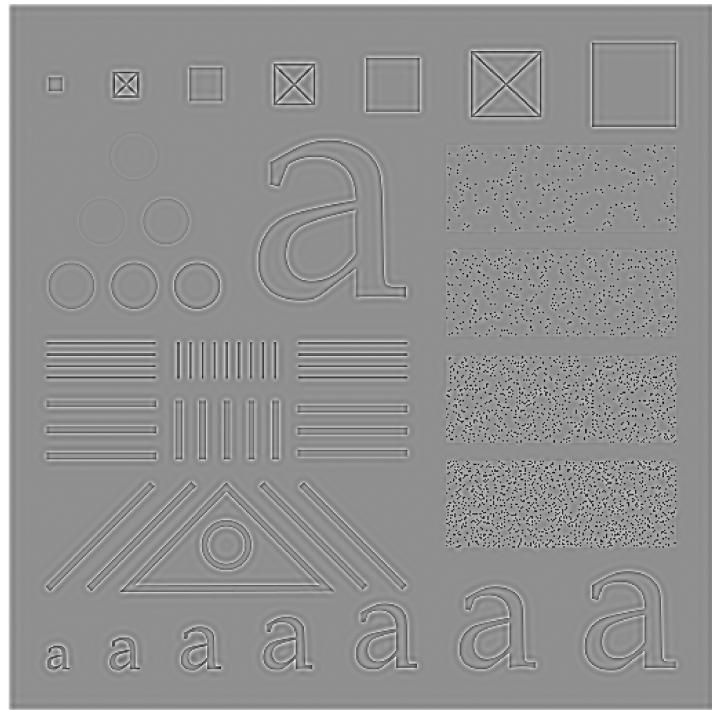
```
%----fc=200-----%
fc=200;
order=5; D=sqrt(U.^2+V.^2);
% high pass
BW_HPF=1./(1+(fc./D).^(2*order));
BW_HPF=ifftshift(BW_HPF);
Image_R=ifft2(BW_HPF.*image_FD);
Image_R2_200=Image_R(1:M, 1:N);
figure; imshow((Image_R2_200),[]);
```



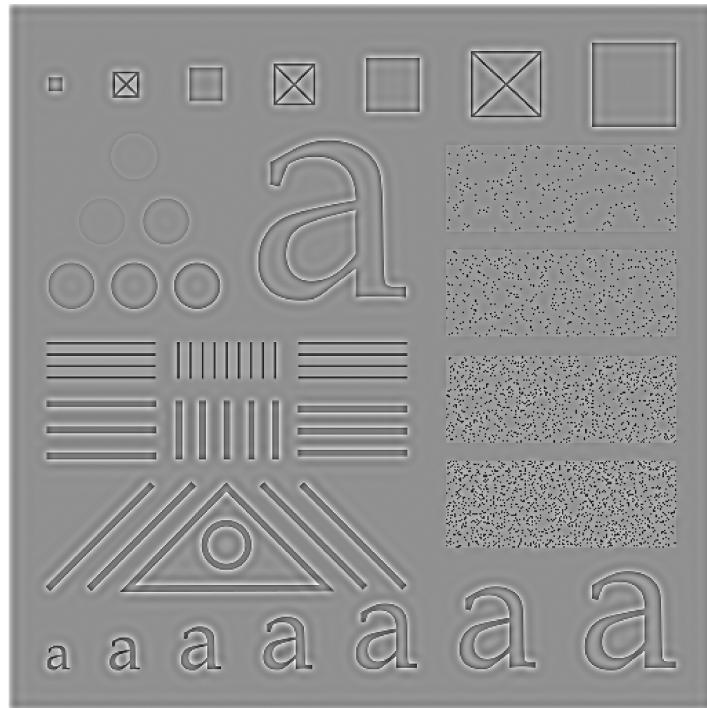
```
%-----fc=250-----%
fc=250;
order=5; D=sqrt(U.^2+V.^2);
% high pass
BW_HPF=1./(1+(fc./D).^(2*order));
BW_HPF=ifftshift(BW_HPF);
Image_R=ifft2(BW_HPF.*image_FD);
Image_R2_250=Image_R(1:M, 1:N);
figure; imshow((Image_R2_250),[]);
```



```
%-----fc=150-----%
fc=150;
order=5; D=sqrt(U.^2+V.^2);
% high pass
BW_HPF=1./(1+(fc./D).^(2*order));
BW_HPF=ifftshift(BW_HPF);
Image_R=ifft2(BW_HPF.*image_FD);
Image_R2_150=Image_R(1:M, 1:N);
figure; imshow((Image_R2_150),[]);
```



```
%-----fc=100-----%
fc=100;
order=5; D=sqrt(U.^2+V.^2);
% high pass
BW_HPF=1./(1+(fc./D).^(2*order));
BW_HPF=ifftshift(BW_HPF);
Image_R=ifft2(BW_HPF.*image_FD);
Image_R2_100=Image_R(1:M, 1:N);
figure; imshow((Image_R2_100),[]);
```



```
%-----MSE-----%
img=double(img)
```

```
img = 512x512
225 225 225 225 225 225 225 225 225 225 225 225 225 225 ...
225 225 224 225 224 225 225 225 224 225 224 225 225 225
225 224 225 225 225 225 225 225 224 225 225 225 225 225
224 225 224 225 225 225 224 225 225 225 225 225 225 225
225 225 225 225 224 225 225 225 225 225 225 225 225 225
225 225 225 225 224 225 225 225 225 225 225 225 225 225
225 225 225 225 224 225 225 225 225 225 225 225 225 224
225 225 225 224 225 225 224 224 224 224 224 225 225 225
224 225 225 225 224 224 225 225 225 225 225 225 224 225
225 224 224 225 224 225 225 225 225 225 224 225 225 224
225 225 225 224 225 225 224 224 225 225 225 224 225 225
.
.
```

```
MSE_BWH_150 = round(immse(Image_R2_150,img))
```

```
MSE_BWH_150 = 45031
```

```
MSE_BWH_180 = round(immse(Image_R2_180,img))
```

```
MSE_BWH_180 = 45197
```

```
MSE_BWH_250 = round(immse(Image_R2_250,img))
```

```
MSE_BWH_250 = 45441
```

```

MSE_BWH_100 = round(immse(Image_R2_100,img))

MSE_BWH_100 = 44532

MSE_BWH_200 = round(immse(Image_R2_200,img))

MSE_BWH_200 = 45277

MSEs =[MSE_BWH_150, MSE_BWH_180, MSE_BWH_250, MSE_BWH_100,MSE_BWH_200]

MSEs = 1x5
    45031      45197      45441      44532      45277

sorted_MSEs=sort(MSEs, "ascend")

sorted_MSEs = 1x5
    44532      45031      45197      45277      45441

table(sorted_MSEs)

ans = 1x1 table

```

	sorted_MSEs				
1	44532	45031	45197	45277	45441

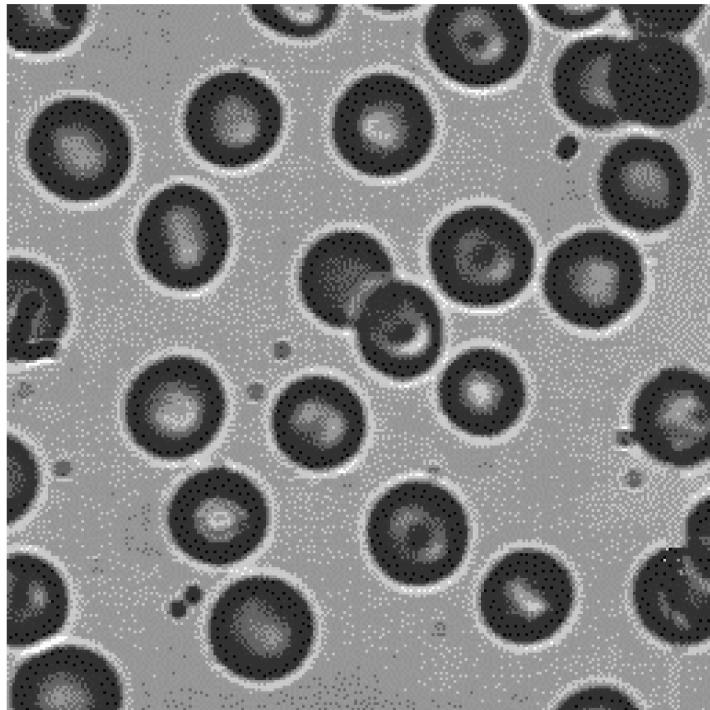
%Comment:This is a highpass filter and we know that high pass filter is  
%made out of lowpass filter in the way that (1-lowpass filter). So the  
%relationship between the cutoff point size and the amount of information  
%(or frequency level) become inverse. If we think about the structure of  
%highpass filter, the area around the origin characterized by the radii  
%length is cut out and the only outside area is kept. When cutoff size  
%increase, the preserved area decreases and error rate increase as a  
%result.

```

%%%2%%%%%
%%a%%

img2=imread("blood.tif");
imshow(img2);

```



```
[M,N]=size(img2)
```

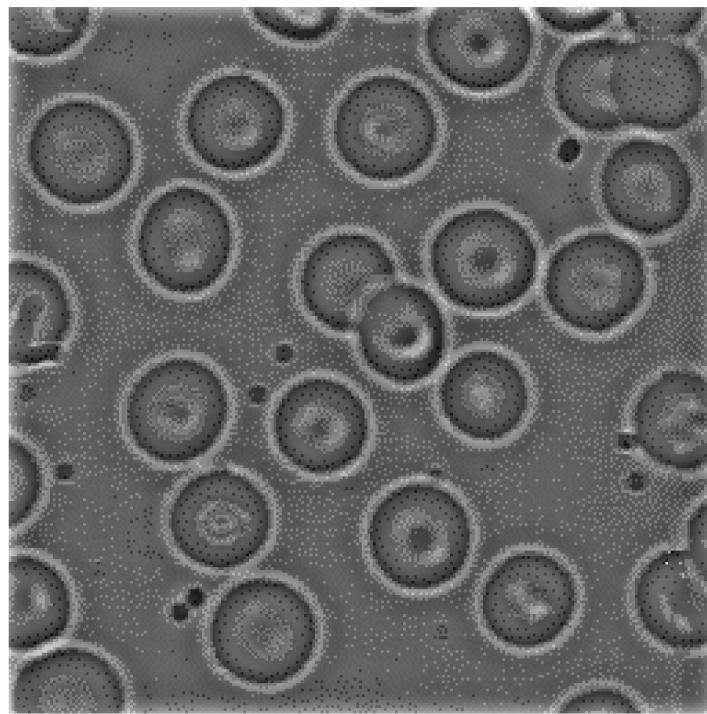
```
M = 256
N = 256
```

```
image_DFT=fft2(img2,2*M,2*N)
```

```
image_DFT = 512x512 complex
106 ×
8.3101 + 0.0000i 0.1261 - 5.3455i -0.0927 - 0.0944i 0.0361 - 1.7814i ...
-0.1341 - 5.3434i -3.2408 + 0.0197i -0.0768 - 0.1901i -1.2540 + 0.0859i
-0.1344 + 0.1224i 0.1244 - 0.0655i -0.2976 + 0.0070i 0.1603 + 0.2437i
0.0293 - 1.6410i -1.0105 - 0.0971i 0.0018 + 0.1326i -0.1420 - 0.1718i
0.0138 - 0.0192i -0.0290 - 0.0732i 0.0308 - 0.0302i -0.0932 - 0.1732i
-0.0971 - 0.9695i -0.5218 + 0.0294i 0.0137 - 0.1472i -0.4015 - 0.0533i
0.0949 + 0.1058i 0.0704 - 0.1850i -0.1944 - 0.1126i -0.1485 + 0.1964i
-0.0208 - 0.7438i -0.3708 - 0.0616i -0.1479 - 0.0217i -0.0156 + 0.1138i
0.1736 + 0.1513i 0.0115 - 0.3982i -0.2252 + 0.0762i 0.0315 - 0.0746i
0.1640 - 0.8539i -0.7168 - 0.0966i -0.0332 + 0.1140i -0.2004 - 0.0188i
:
:
```

```
[U,V]=meshgrid(-M:1:M-1,-N:1:N-1);
fc=30;
order=3; D=sqrt(U.^2+V.^2);
% high pass
BW_HPF=1./(1+(fc./D).^(2*order));
BW_HPF=ifftshift(BW_HPF);
Image_R=ifft2(BW_HPF.*image_DFT);
```

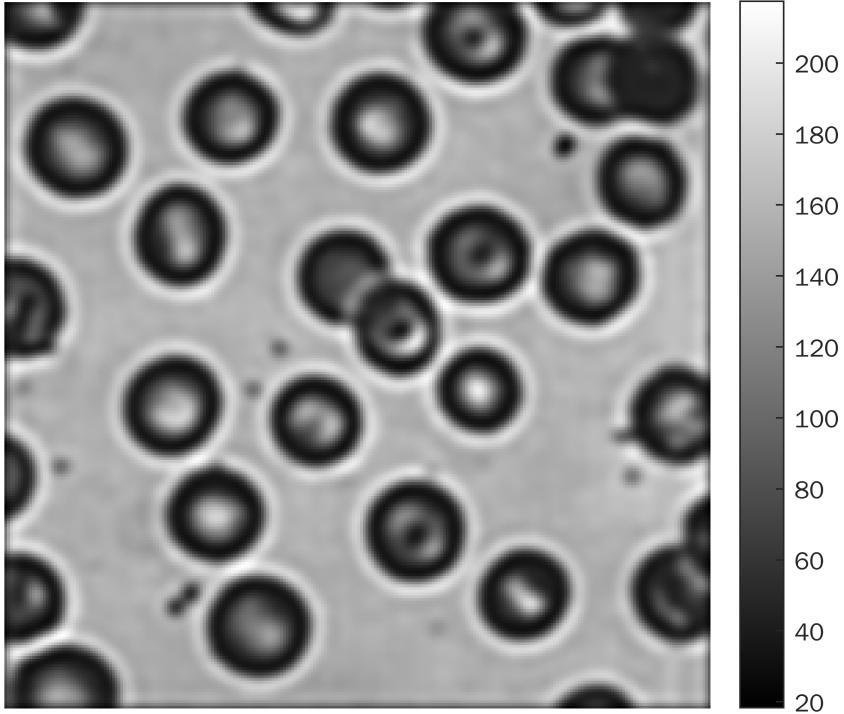
```
Image_R2=Image_R(1:M, 1:N);
figure; imshow((Image_R2),[ ])
```



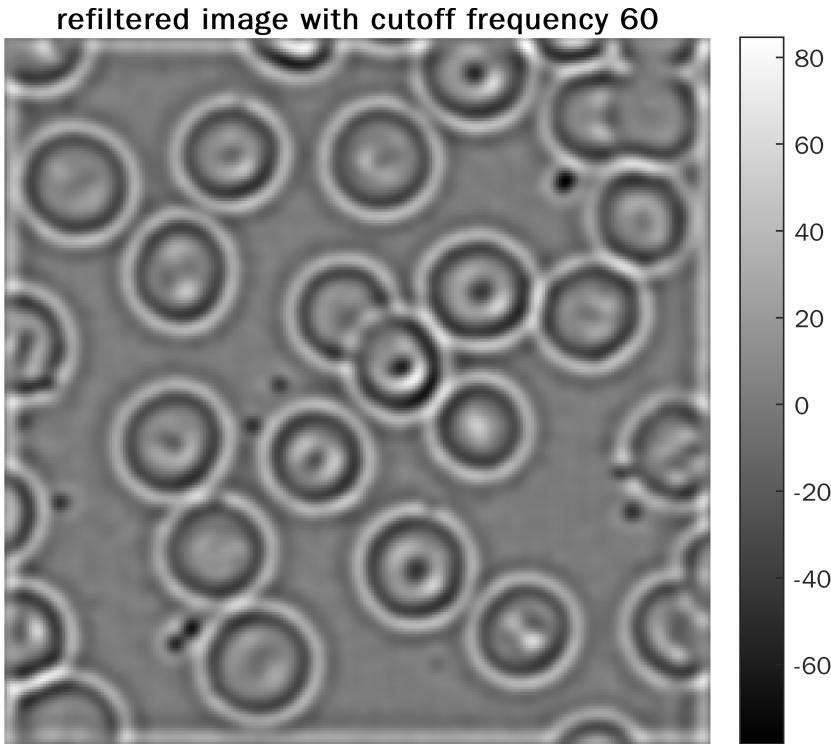
```
%%b%%
fc=60;
order=3; D=sqrt(U.^2+V.^2);

BW_LPF=1./(1+(D/fc).^(2*order));
BW_LPF=ifftshift(BW_LPF);
Image_R=ifft2(BW_LPF.*image_DFT);
Image_R1=Image_R(1:M, 1:N);
figure; imshow(Image_R1,[ ]);colorbar;
title(['filtered image with cutoff frequency ',num2str( fc)]);
```

filtered image with cutoff frequency 60



```
%apply highpass to lowpass filtered image%
Image_R3=ifft2(BW_HPF.*BW_LPF.*image_DFT);
Image_R3=Image_R3(1:M, 1:N);
figure; imshow(Image_R3,[ ]);colorbar;
title(['refiltered image with cutoff frequency ',num2str( fc)]);
```



%%C%%

```

fc=60;
order=3; D=sqrt(U.^2+V.^2);
%low pass
BW_LPF=1./(1+(D/fc).^(2*order));
BW_LPF=ifftshift(BW_LPF);

fc=30;
order=3; D=sqrt(U.^2+V.^2);
% high pass
BW_HPF=1./(1+(fc./D).^(2*order));
BW_HPF=ifftshift(BW_HPF);

%combination%
BW_LHPF=BW_LPF.*BW_HPF

```

BW_LHPF = 512x512								
0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	
0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	
0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0004	
0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0003	0.0006	
0.0001	0.0001	0.0001	0.0001	0.0002	0.0003	0.0005	0.0008	
0.0002	0.0002	0.0002	0.0003	0.0004	0.0006	0.0008	0.0013	
0.0004	0.0004	0.0004	0.0005	0.0007	0.0010	0.0014	0.0020	

```
0.0007    0.0008    0.0008    0.0010    0.0013    0.0016    0.0022    0.0030
```

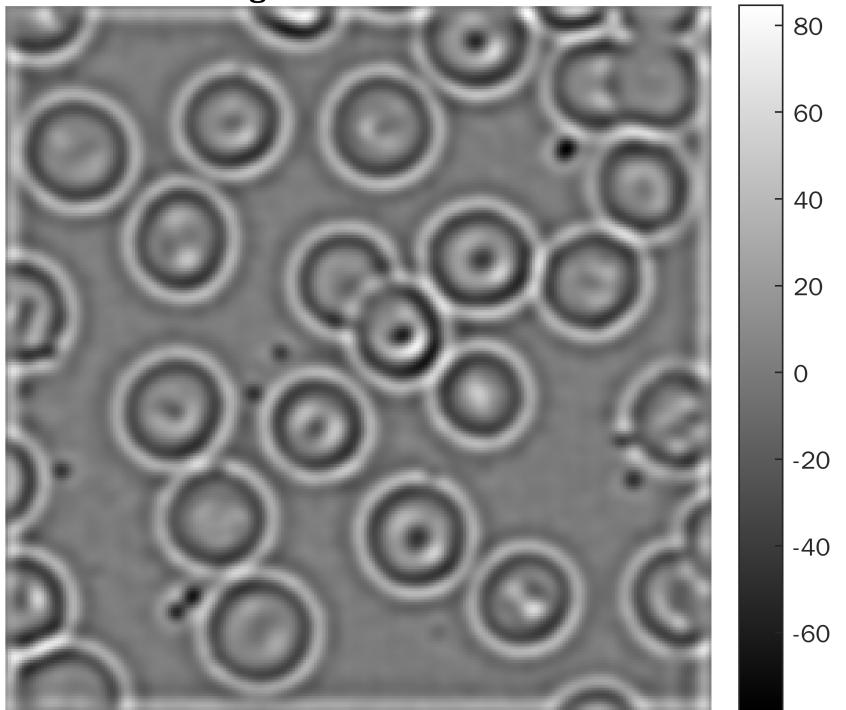
```
.
```

```
Image_R5=ifft2( BW_LHPF.*image_DFT )
```

```
Image_R5 = 512x512
2.4122    4.5884    5.4736    5.3600    4.8121    4.1736    3.5817    3.2575 ...
5.4028    8.8702   10.7271   11.3621   11.5434   11.7994   12.4094   13.5555
6.5733   10.5839   12.7055   13.3781   13.6011   14.1886   15.5310   17.7615
6.0960   9.9649   11.7280   11.8440   11.5066   11.8382   13.3764   16.1330
4.8611   8.2430   9.3277   8.5967   7.4025   7.1016   8.3540   11.1030
3.6874   6.5988   6.9812   5.4066   3.3703   2.3366   3.0228   5.3527
2.7618   5.3707   5.2784   3.1238   0.4835   -1.2061   -1.2179   0.4399
1.8182   4.2962   4.0450   1.6791   -1.2573   -3.4196   -4.0958   -3.2243
0.5585   2.9506   2.7014   0.3320   -2.7561   -5.2516   -6.4517   -6.3117
-0.9945  1.1529   0.6472   -1.9926   -5.4039   -8.2663   -9.8814   -10.2385
.
.
```

```
Image_R5=Image_R5(1:M, 1:N);
figure; imshow(Image_R5,[]);colorbar;
title(['filtered image with combined filter ',num2str( fc)]);
```

filtered image with combined filter 30



```
%%d%%
```

```
%----MSE----%
```

```
img2=double(img2)
```

```
img2 = 256x256
 49   49   49   49   55   98   98   98   104   147   104   147 ...
 49   49   49   55   98   55   98  104   98   104   147   104   153
 49   49   49   49   49   98   55   98  104   98   104   104   147
 49   49   49   49   55   49   98   98   98  104  141   104   147
 49   6    49   49   49   55   55   98   98   98  104  141   104   104
 49   49   49   49   49   55   92   98   98   98  104  141   104   104
 49   49   49   49   49   55   55   98   55   98  104   104   98
 49   49   49   6    49   49   55   98   98   98  98   98  104
 49   49   49   55   49   49   55   49   49   55  55   55   55   98
 49   6    49   49   49   55   49   92   55   49   49   49   98   49
```

```
MSE_lowpassed = round(immse(Image_R1,img2))
```

```
MSE_lowpassed = 377
```

```
MSE_lowpassed_highpassed = round(immse(Image_R3,img2))
```

```
MSE_lowpassed_highpassed = 17843
```

```
MSE_combination = round(immse(Image_R5,img2))
```

```
MSE_combination = 17843
```

```
MSEs =[MSE_lowpassed, MSE_lowpassed_highpassed, MSE_combination]
```

```
MSEs = 1x3
 377       17843      17843
```

```
sorted_MSEs=sort(MSEs, "ascend")
```

```
sorted_MSEs = 1x3
 377       17843      17843
```

```
table(sorted_MSEs)
```

```
ans = 1x1 table
```

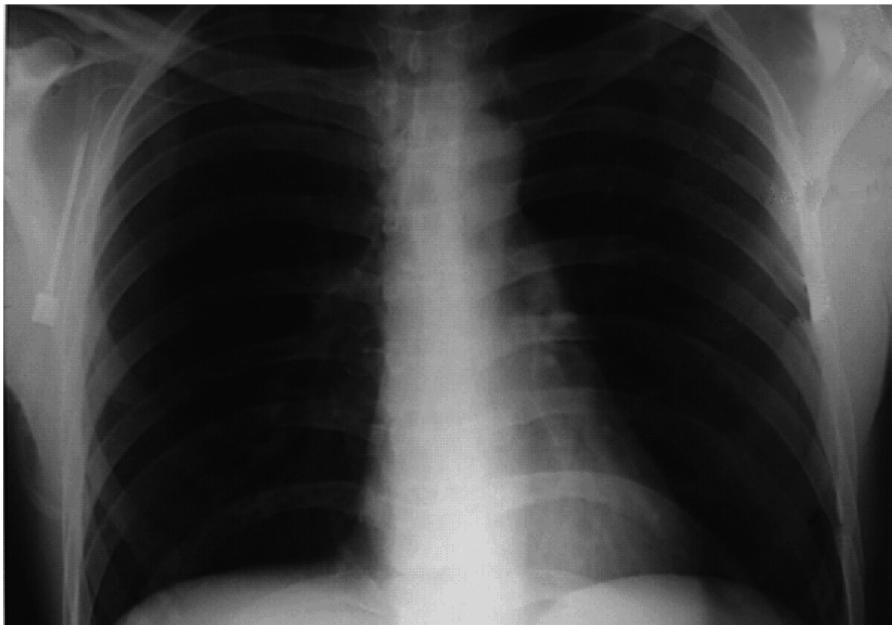
	sorted_MSEs		
1	377	17843	17843

```
%Comment: MSE for image filtered with lowpass then highpassed respecitely
%has the same error rate with the image filtered with combined filter
%consisting of highpass and lowpass filter.
```

```
%%%3%%%
```

```
%%first%%
```

```
img3=imread("chestXray-dark.tif");
imshow(img3);
```



```
[M,N]=size(img3)
```

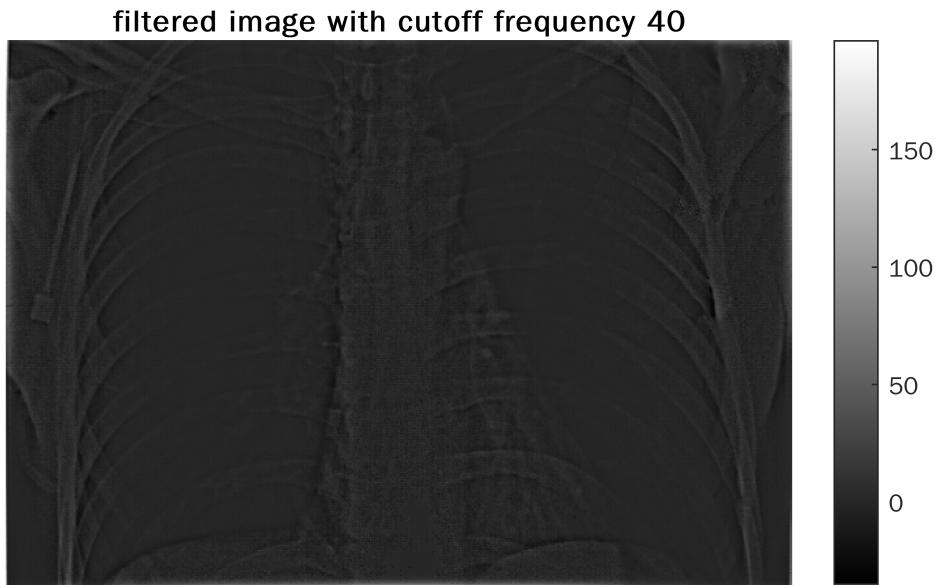
```
M = 418  
N = 602
```

```
image_FD=fft2(img3,2*M,2*N)
```

```
image_FD = 836x1204 complex  
107 ×  
1.5119 + 0.0000i -0.0520 - 0.9531i -0.0907 + 0.0794i 0.0676 + 0.0713i ...  
-0.1079 - 0.9296i -0.6003 + 0.2518i 0.4222 - 0.0077i -0.0693 - 0.3052i  
0.0639 + 0.0141i 0.1163 - 0.0671i -0.1333 - 0.2993i -0.2348 + 0.1178i  
-0.1271 - 0.3385i -0.2494 + 0.1165i 0.0438 + 0.1018i 0.0574 - 0.0099i  
0.0425 + 0.0791i 0.1044 - 0.0390i -0.0317 - 0.1362i -0.1082 + 0.0149i  
-0.0667 - 0.2163i -0.1770 + 0.0636i 0.0275 + 0.0730i 0.0299 + 0.0069i  
0.0299 + 0.0662i 0.0819 - 0.0108i -0.0026 - 0.1004i -0.0749 - 0.0070i  
-0.0521 - 0.1555i -0.1210 + 0.0459i 0.0122 + 0.0432i 0.0091 + 0.0213i  
0.0359 + 0.0637i 0.0726 - 0.0206i -0.0079 - 0.0797i -0.0473 - 0.0079i  
-0.0435 - 0.1372i -0.1106 + 0.0330i -0.0017 + 0.0403i -0.0012 + 0.0232i  
:  
:
```

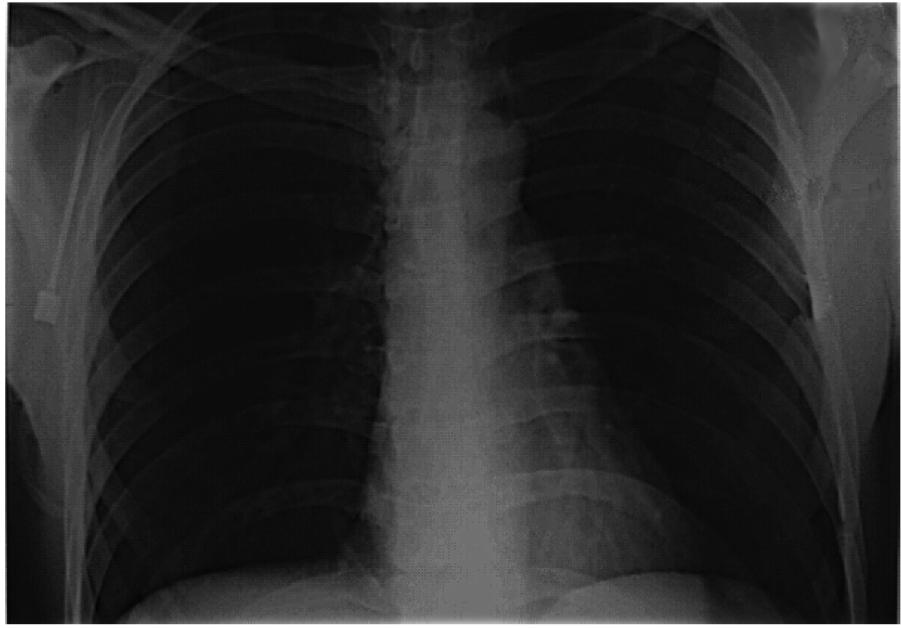
```
[U,V]=meshgrid(-N:1:N-1,-M:1:M-1);  
% step1  
fc=40;  
Gau_F=1-exp(-(U.^2+V.^2)/2/fc^2);  
Gau_F=ifftshift(Gau_F);  
Image_R=ifft2(Gau_F.*image_FD);  
Image_R=Image_R(1:M, 1:N);
```

```
figure; imshow(Image_R,[ ]);colorbar;
title(['filtered image with cutoff frequency ',num2str( fc)]);
```

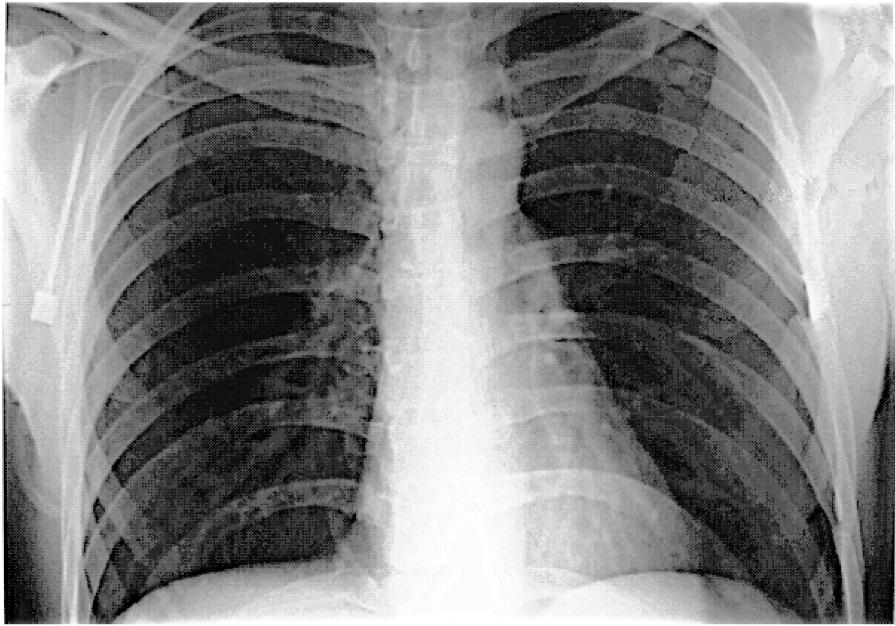


%step2

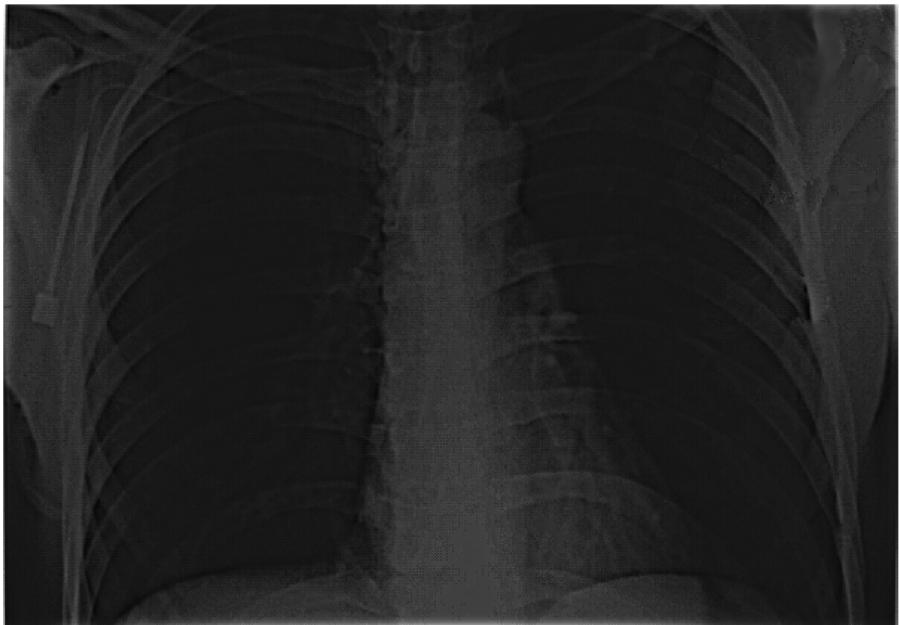
```
Image_emphasized=0.5.*double(img3)+0.75.*Image_R;
imshow(Image_emphasized,[ ]);
```



```
image_final=histeq(uint8(Image_emphasized));
imshow(image_final);
```



```
%%second%%
fc=40;
Gau_F=1-exp(-(U.^2+V.^2)/2/fc^2);
Gau_F=ifftshift(Gau_F);
Image_R_high_freq_emp=ifft2((1+ 5*Gau_F).*image_FD);
Image_R_high_freq_emp=Image_R_high_freq_emp(1:M, 1:N);
imshow(Image_R_high_freq_emp,[ ]);
```



```
image_final2=histeq(uint8(Image_R_high_freq_emp));
imshow(image_final2);
```

