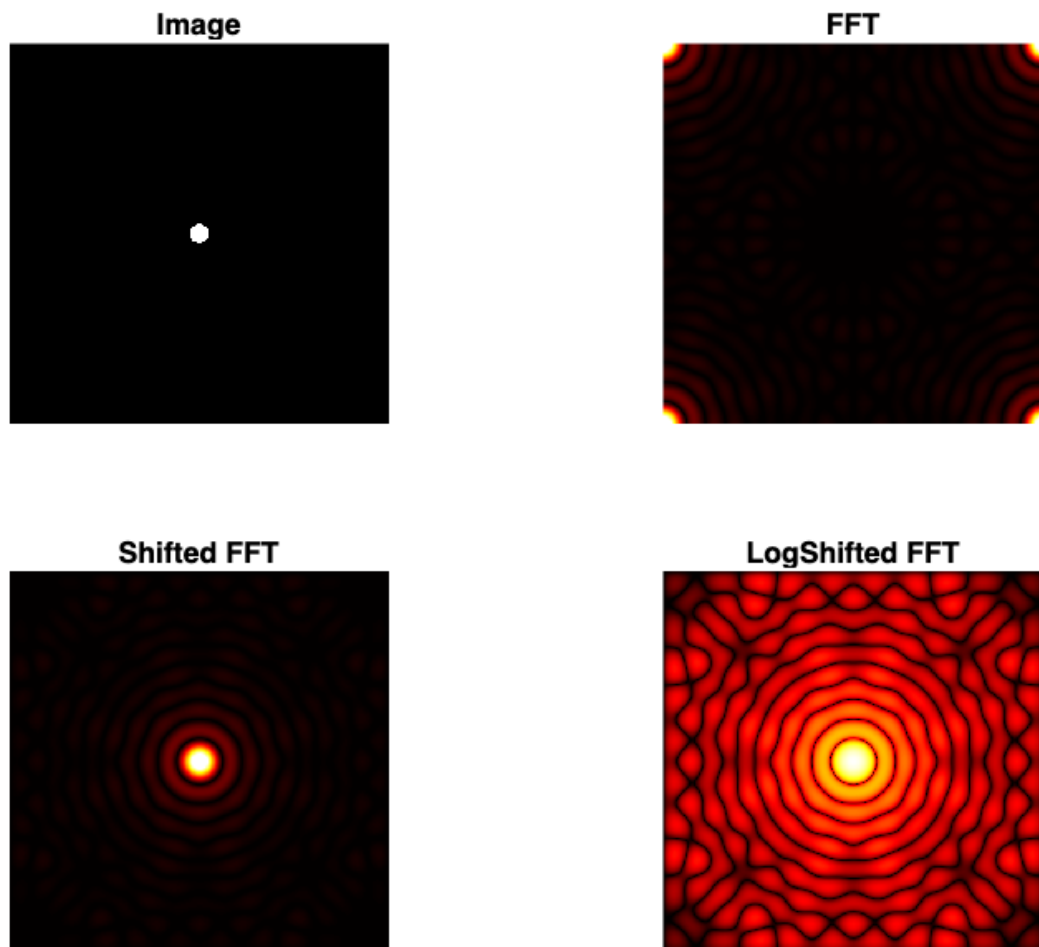


Activity 2. Fourier Transform Model of Image Formation

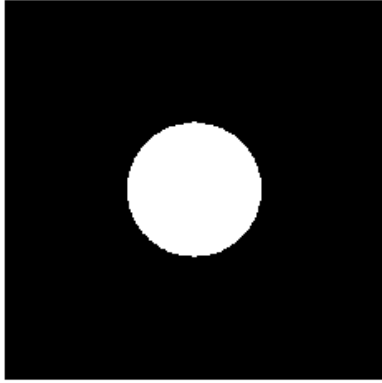
Activity 2.1 Familiarization with Discrete Fourier Transform

```
Fourier_transform(GraphCircle(0.01));
```

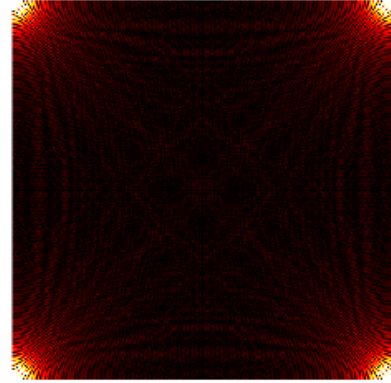


```
Fourier_transform(GraphCircle(0.5));
```

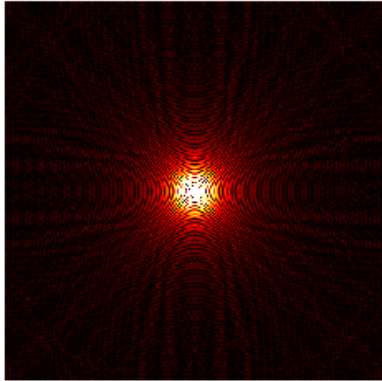
Image



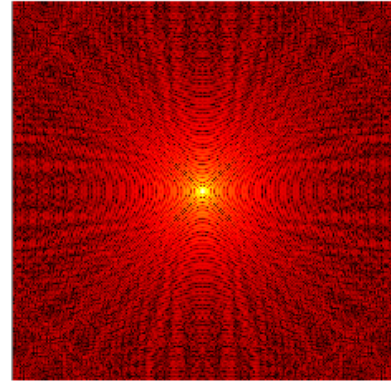
FFT



Shifted FFT

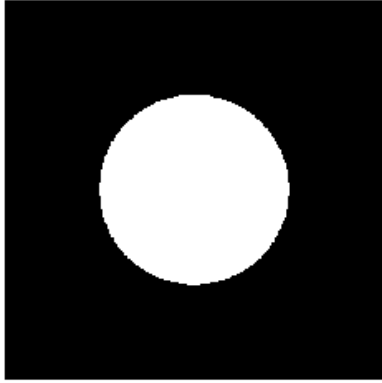


LogShifted FFT

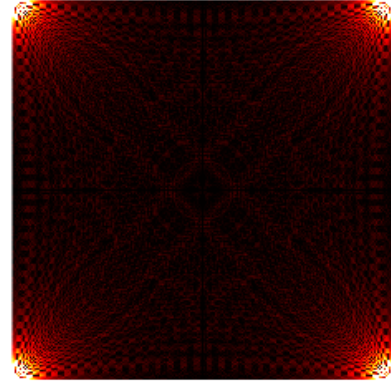


```
Fourier_transform(GraphCircle(1));
```

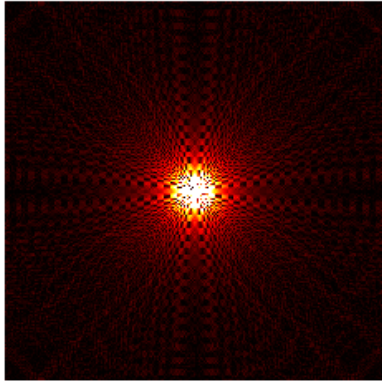
Image



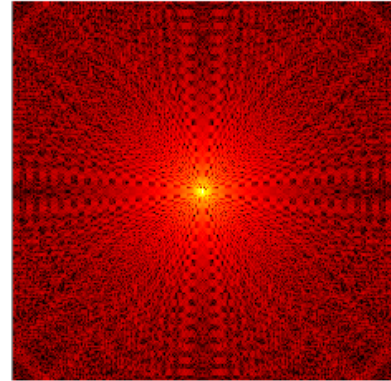
FFT



Shifted FFT

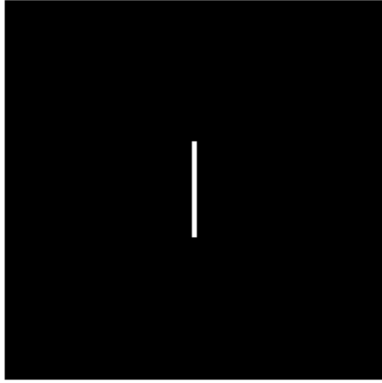


LogShifted FFT

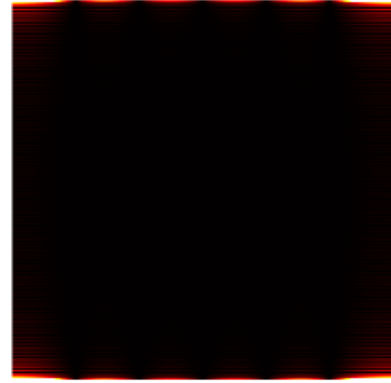


```
Fourier_transform(single_slit(5));
```

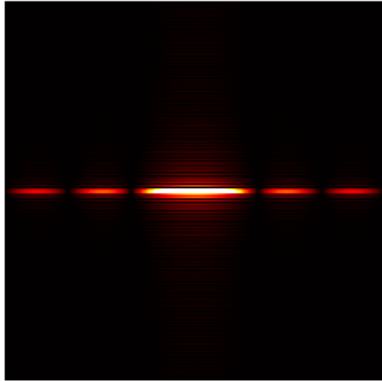
Image



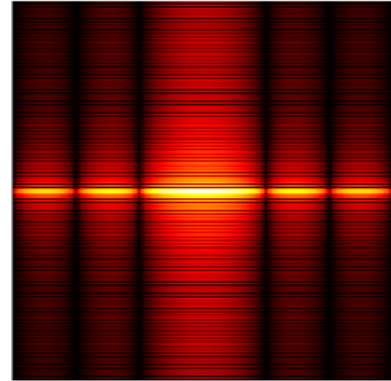
FFT



Shifted FFT

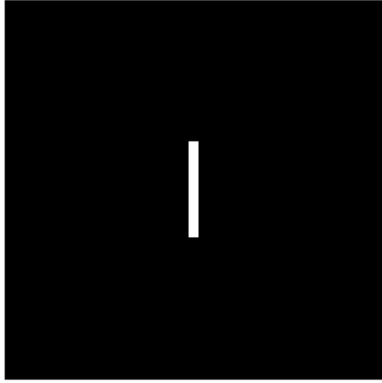


LogShifted FFT

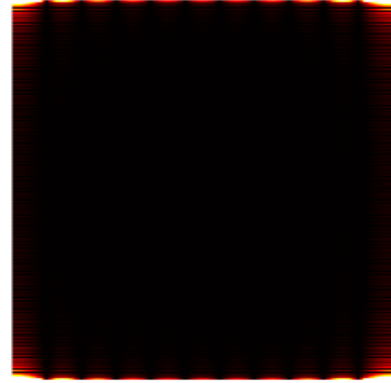


```
Fourier_transform(single_slit(10));
```

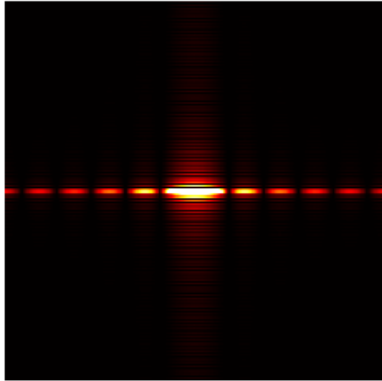
Image



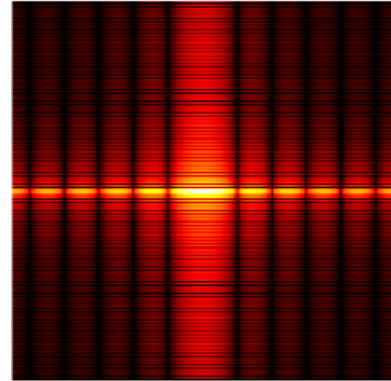
FFT



Shifted FFT

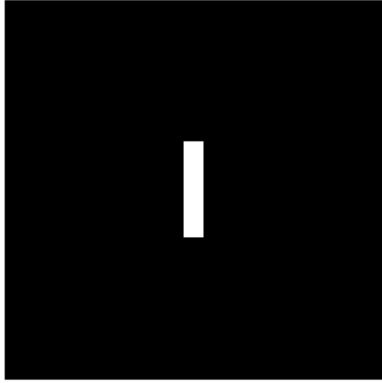


LogShifted FFT

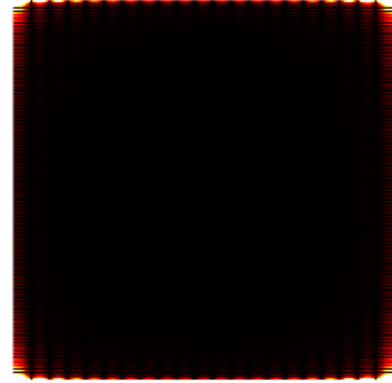


```
Fourier_transform(single_slit(20));
```

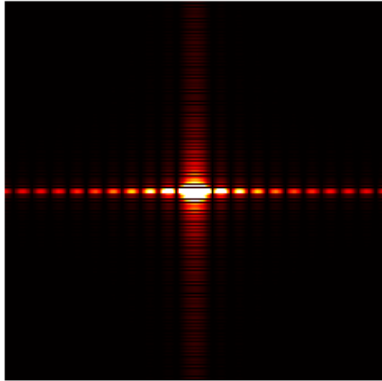
Image



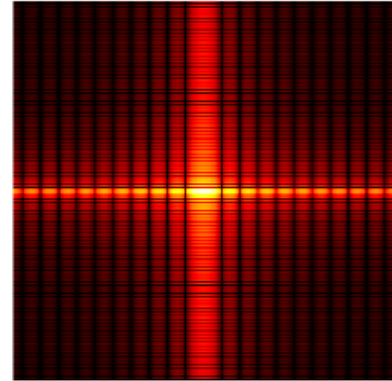
FFT



Shifted FFT

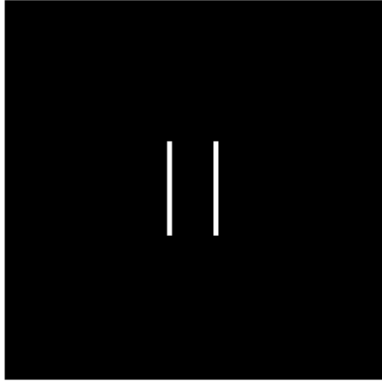


LogShifted FFT

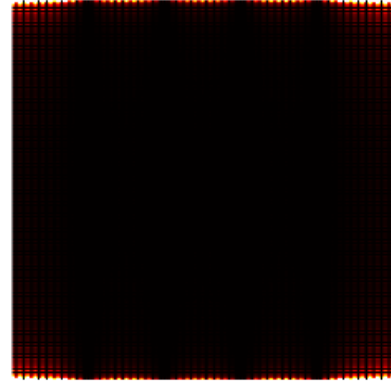


```
Fourier_transform(doubleSlitImage1(5));
```

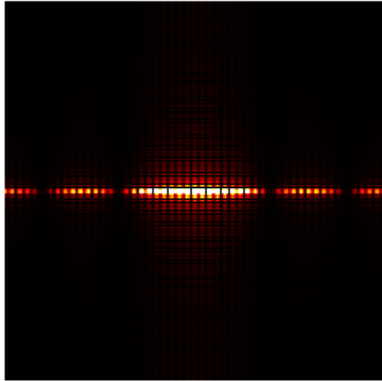
Image



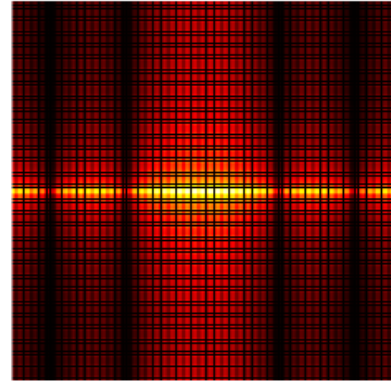
FFT



Shifted FFT

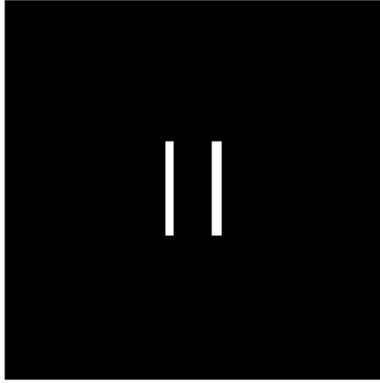


LogShifted FFT

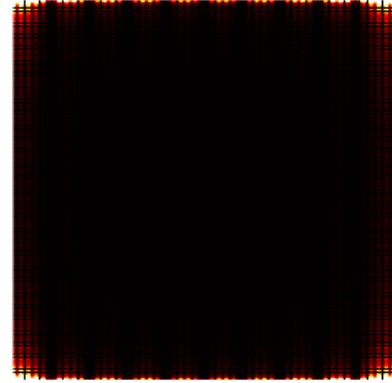


```
Fourier_transform(doubleSlitImage1(10));
```

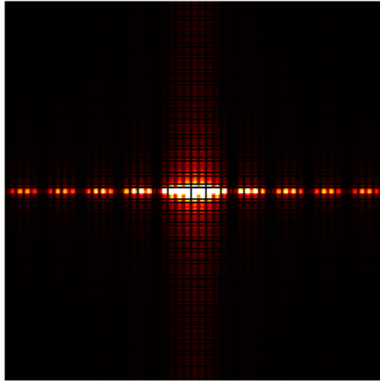
Image



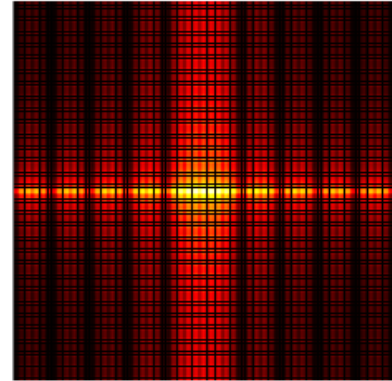
FFT



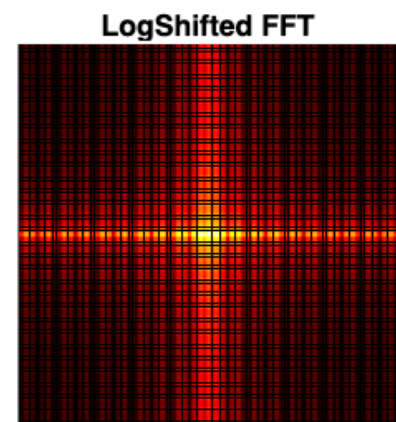
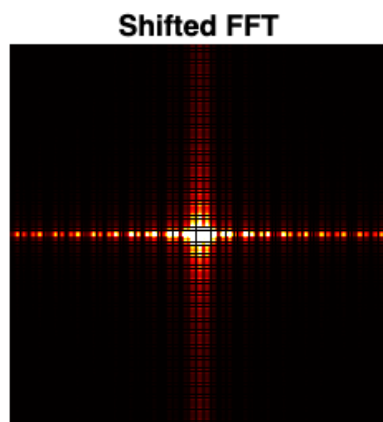
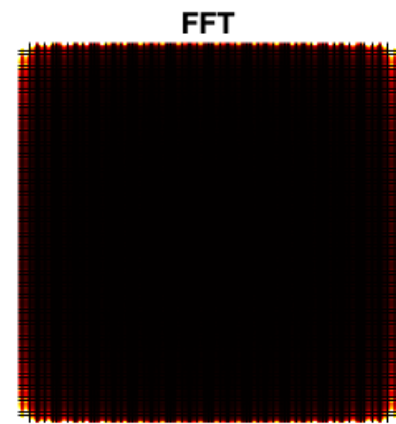
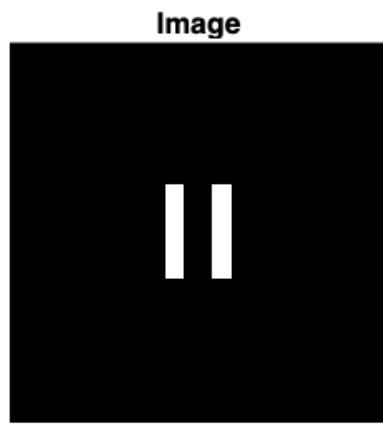
Shifted FFT



LogShifted FFT



```
Fourier_transform(doubleSlitImage1(20));
```

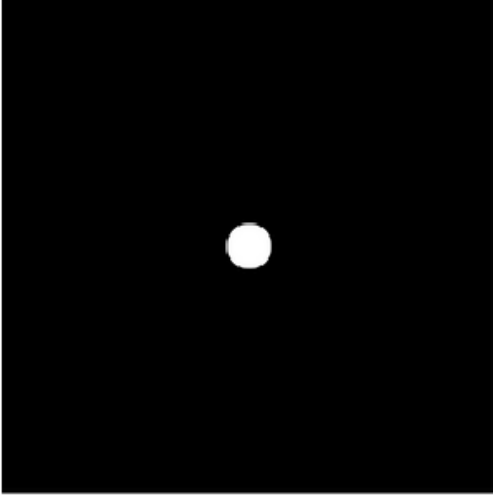
```
I = rgb2gray(imread('IDPic.jpg'));
figure();
subplot(1,3,1);
imshow(I);
Irec = fft2 (fft2(I));
subplot(1,3,2);
imagesc(abs(Irec));
colormap gray;
axis off;
axis image;
Irec2 = ifft2(fft2(I));
subplot(1,3,3);
imagesc(abs(Irec2));
colormap gray;
axis image;
axis off;
```



Activity 2.2 Simulation of an imaging system

```
Convolution('1.png');
```

Hole

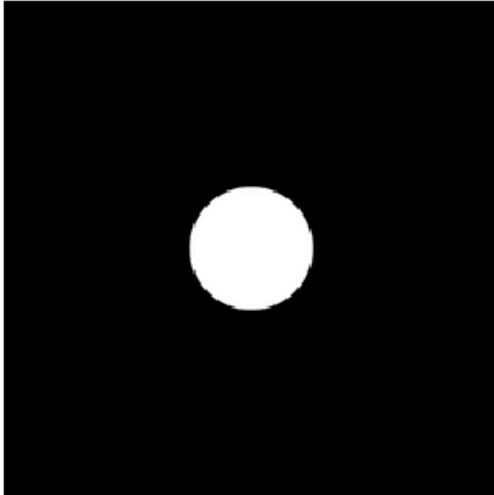


Reconstructed



```
Convolution('2.png');
```

Hole

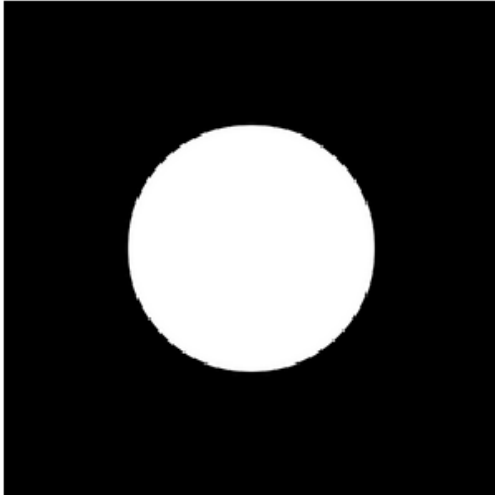


Reconstructed



```
Convolution('3.png');
```

Hole

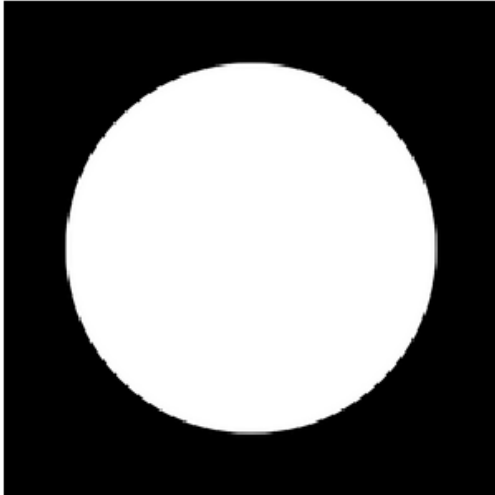


Reconstructed



```
Convolution('4.png');
```

Hole

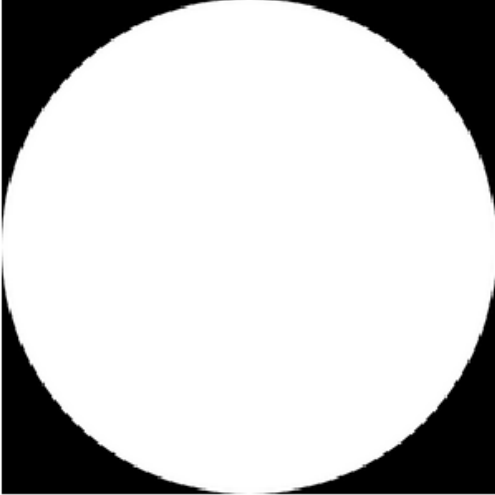


Reconstructed



```
Convolution('5.png');
```

Hole

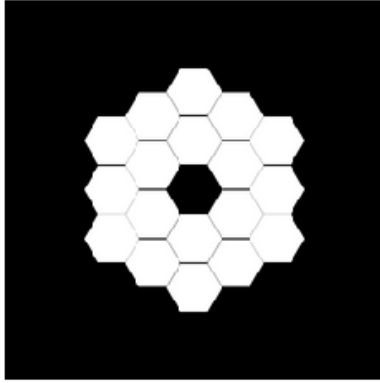


Reconstructed

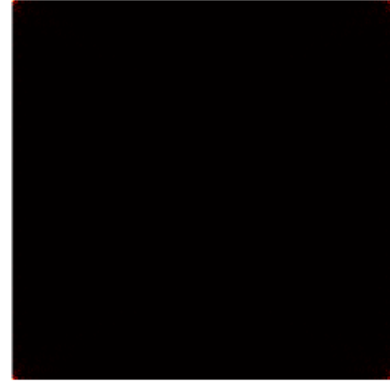


```
JWT('JWT Primary Mirror.png');
```

Image



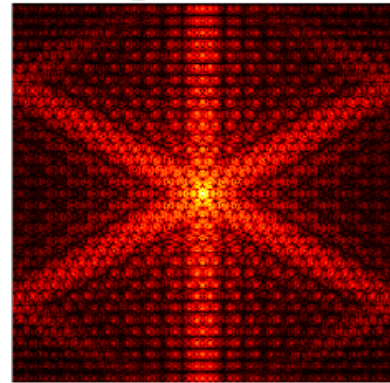
FFT



Shifted FFT

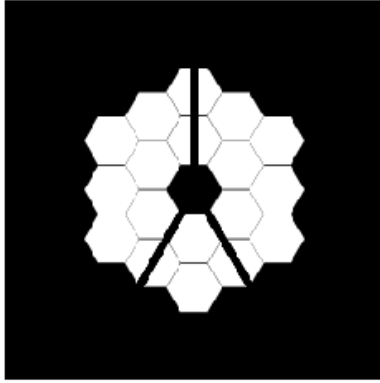


LogShifted FFT

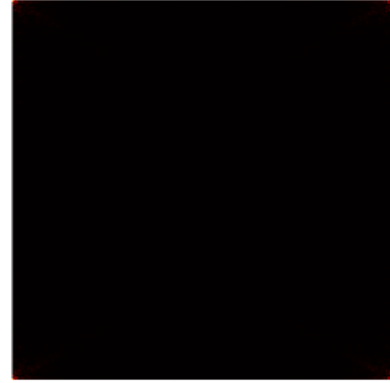


```
JWST('JWST Primary Mirror2.png');
```


Image



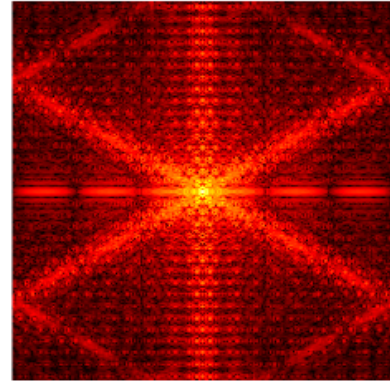
FFT



Shifted FFT

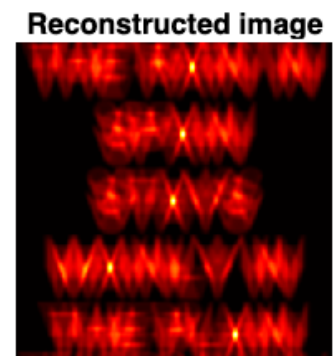
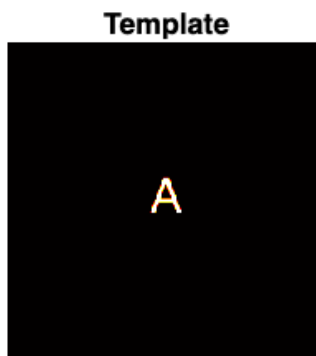


LogShifted FFT

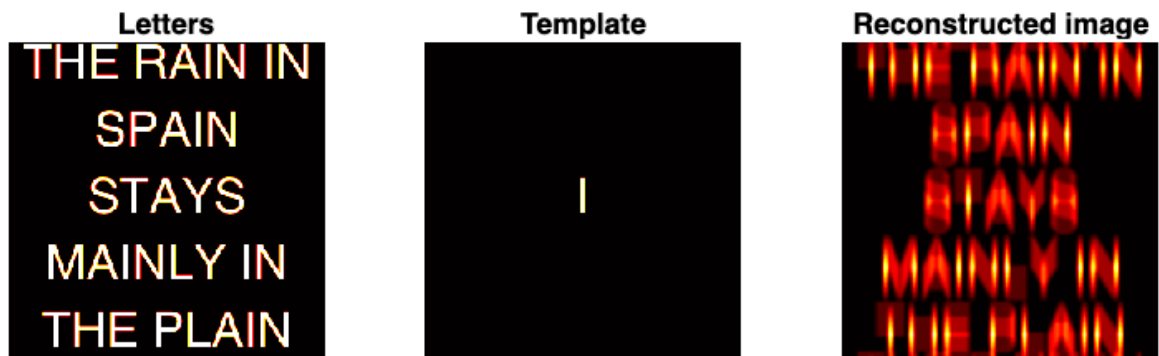


Activity 2.3 Correlation

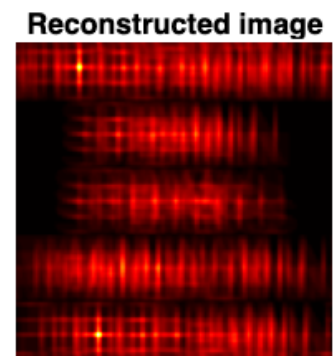
```
correlation('a.png');
```



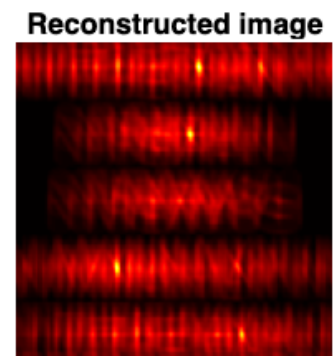
```
correlation('i.png');
```



```
correlation('the.png');
```



```
correlation('rain.png');
```



```
correlation('spain.png');
```



The functions used above are created in the lines below:

```
function Fourier_transform(aperture)
    Fourier_transform = fft2(aperture);
    Fourier_Mag = abs(Fourier_transform);
    shifted_Fourier_transform = fftshift(Fourier_transform);
    mag_shift_FourierT = abs(shifted_Fourier_transform);
    log_mag_shift_FT = rescale(log(mag_shift_FourierT+1),0,256);
    fig = figure;
    img1 = Fourier_Mag;
    img2 = mag_shift_FourierT;
    img3 = log_mag_shift_FT;
    im = aperture;
    colormap('hot');
    subplot(2,2,1);
    im = imshow(aperture);
    title('Image');
```

```

subplot(2,2,2);
image(img1);
axis off;
axis image;
title('FFT');

subplot(2,2,3);
image(img2);
axis off;
axis image;
title('Shifted FFT');

subplot(2,2,4);
image(img3);
axis off;
axis image;
title('LogShifted FFT');
end

```

```

function slit_image = single_slit(d)

```

```

% Create an L x L matrix of zeros

```

```

slit_image = zeros(400, 400);

```

```

% Calculate the x-coordinates of the slit

```

```

x = [200 - d/2, 200 + d/2];

```

```

% Loop through the x-coordinates of the slit

```

```

for i = round(x(1)) : round(x(2))

```

```

    % Loop through the y-coordinates of the slit

```

```

    for j = round(200 - 100/2) : round(200 + 100/2)

```

```

        % Set the pixels within the central region to 1

```

```

        if i >= round(x(1) + (x(2) - x(1) - d)/2) && i <= round(x(1) + (x(2) - x(1) + d)/2)
            slit_image(j, i) = 1;

```

```

        end

```

```

    end

```

```

end

```

```

end

```

```

function image = doubleSlitImage1(slitWidth)

```

```

% create a blank image with the specified dimensions

```

```

image = zeros(400, 400);

```

```

% calculate the x-coordinate ranges of the slits

```

```

slit1Left = floor(175 - slitWidth/2);
slit1Right = slit1Left + slitWidth - 1;
slit2Left = floor(225 - slitWidth/2);
slit2Right = slit2Left + slitWidth - 1;

% set the values in the image corresponding to the slits
for i = 1:400
    if i >= slit1Left && i <= slit1Right
        startRow = floor(150);
        endRow = startRow + 100 - 1;
        image(startRow:endRow, i) = 1;
    end
    if i >= slit2Left && i <= slit2Right
        startRow = floor(150);
        endRow = startRow + 100 - 1;
        image(startRow:endRow, i) = 1;
    end
end
end

function Convolution(hole)
    A = imread(hole);
    A = im2double(A);
    Ashift = fftshift(A);
    Image = imread('NIP_letter.tiff');
    Image = im2double(Image);
    FImage = fft2(Image(:,:,1));
    H = Ashift .* FImage;
    h = ifft2(H);
    subplot(1,2,1); image(A); axis off ; axis image; title('Hole');
    subplot(1,2,2); imagesc(abs(h)); colormap gray; axis image; axis off; title('Recons
end

function JWST(pic)
    A = rgb2gray(im2double(imread(pic)));
    Fourier_transform = fft2(A);
    Fourier_Mag = abs(Fourier_transform);
    shifted_Fourier_transform = fftshift(Fourier_transform);
    mag_shift_FourierT = abs(shifted_Fourier_transform);
    log_mag_shift_FT = rescale(log(mag_shift_FourierT+1),0,256);
    fig = figure;
    img1 = Fourier_Mag;
    img2 = mag_shift_FourierT;
    img3 = log_mag_shift_FT ;
    im = pic;
    subplot(2,2,1);
    im = imshow(pic);
    title('Image');

```



```

subplot(2,2,2);
imagesc(img1);
colormap hot;
axis off;
axis image;
title('FFT');

subplot(2,2,3);
imagesc(img2);
colormap hot;
axis off;
axis image;
title('Shifted FFT');

subplot(2,2,4);
imagesc(img3);
axis off;
axis image;
title('LogShifted FFT');
end

function [a,b,c] = correlation(letter)
    I = im2gray(imread('text.png'));
    A = im2gray(imread(letter));
    Afft2 = fft2(A);
    Ifft2 = fft2(I);
    P = conj(Afft2) .* Ifft2 ;
    smallp = ifft2(P);
    reconstruction = fftshift(abs(smallp));
    a = subplot(1,3,1); image(I); axis image; axis off; title('Letters');
    b = subplot(1,3,2); image(A); axis image; axis off; title('Template');
    c = subplot(1,3,3); imagesc(reconstruction); axis image; axis off; title('Reconstruction');
end

function A = GraphCircle(r)
    N = 400;
    x = linspace(-2,2,N);
    y = x;
    [X,Y] = meshgrid(x,y);
    R = (X.^2 + Y.^2);
    A = zeros(size(R));
    A(R<r) = 1;
end

```