

Question 1a:

```
I = imread('HW4_images/HW04_input.png');

%resize image to the next powers of 2
I = im2double(imresize(I,[2^nextpow2(size(I,1)) 2^nextpow2(size(I,2))]));

figure;
imshow(I, [ ]);
```



```
%out-of-focus blur
kernel = fspecial('average', 5);

%applying the filter
blurred_image = imfilter(I, kernel, 'symmetric');

figure;

subplot(1,2,1);
imshow(I, []);
title("Original Image");

subplot(1,2,2);
imshow(blurred_image, []);
```

```
title("Blurred Image");
```

Original Image



Blurred Image



```
%creating DFT for the blur
kernel_dft = fft2(kernel, size(blurred_image, 1), size(blurred_image, 2));

%extracting the original image using inverse filter
original_image = real(ifft2(fft2(blurred_image) ./ kernel_dft));
original_image_restored = im2uint8(original_image);

figure;
imshow(original_image_restored);
title("restored image", FontSize=8);
```



Inverse filtering is essentially the exact inverse of the blurring process, so without the limitations of precision of computation it should produce an exact restoration of the original image in the absence of noise.

Question 1b:

$$\text{As given, SNR} = 10 \log_{10} \frac{P_{ss}}{P_{vv}}$$

Now Solving for P_{vv} , we get

$$P_{vv} = \frac{P_{ss}}{\frac{\text{SNR}}{10^{10}}}$$

Putting the values, we get,

$$P_{vv} = \frac{P_{ss}}{10^3}$$

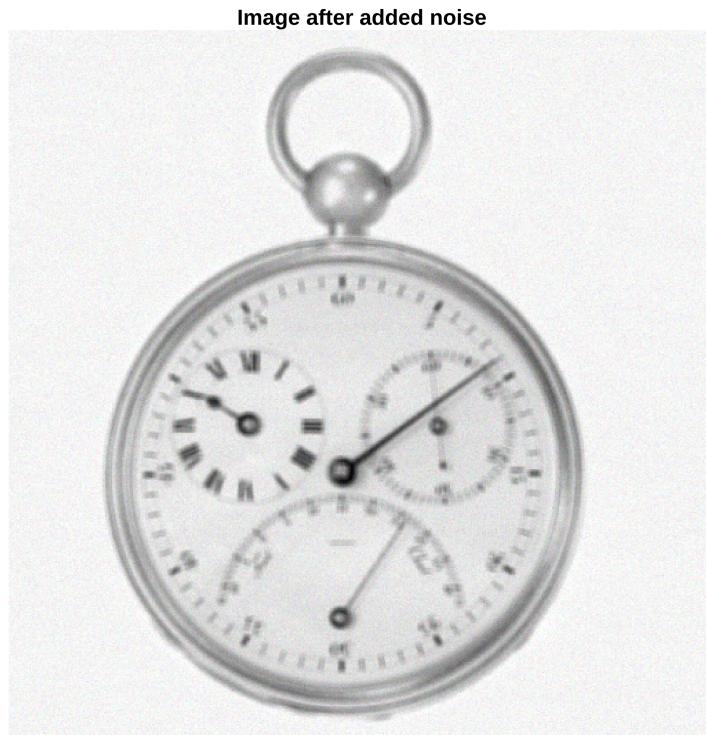
```

Pss = rms(blurred_image, "all") .^ 2;
Pvv = Pss / 1000;

noisy_blurred_image = imnoise(blurred_image, "gaussian", 0, Pvv);

```

```
figure;  
imshow(noisy_blurred_image);  
title("Image after added noise", FontSize = 8);
```



```
psnr_blurred_with_original_ref = psnr(blurred_image, I)
```

```
psnr_blurred_with_original_ref = 23.1327
```

```
psnr_noisy_blurred_with_original_ref = psnr(noisy_blurred_image, I)
```

```
psnr_noisy_blurred_with_original_ref = 22.5136
```

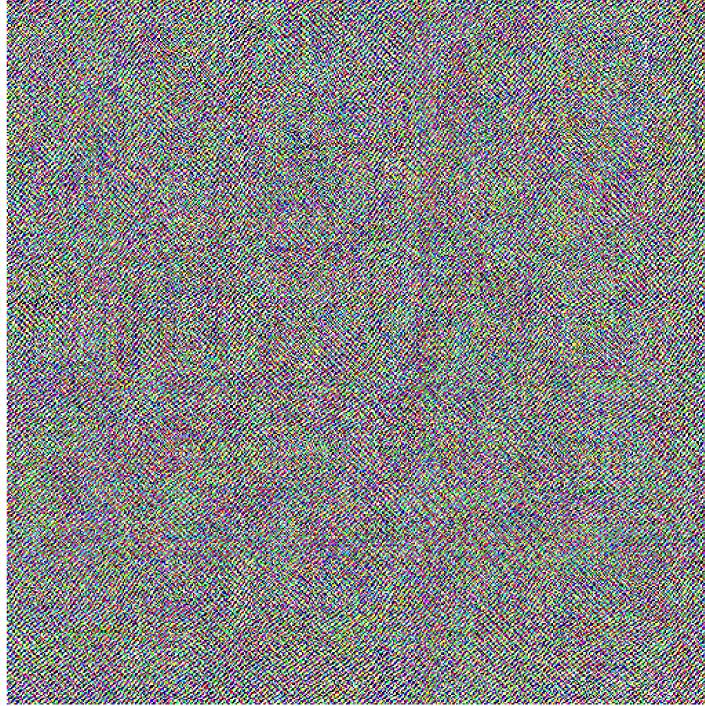
```
psnr_noisy_blurred_with_blurred_ref = psnr(noisy_blurred_image, blurred_image)
```

```
psnr_noisy_blurred_with_blurred_ref = 31.3286
```

Question 2:

```
% Try restoration using Least Squares Filtering.  
original_image_from_noisy_blurred = real(ifft2(fft2(noisy_blurred_image) ./ (kernel_dft  
  
figure;  
imshow(original_image_from_noisy_blurred, []);  
title("Restored image from noisy blurred image using Inverse filter", FontSize=8);
```

Restored image from noisy blurred image using Inverse filter



Question 3:

```
noisy_image_blurred_fft = fft2(noisy_blurred_image);
kernel_otf = psf2otf(kernel, [size(blurred_image, 1), size(blurred_image, 2)]);

% Try restoration using Least Squares Filtering.
laplacian_1 = fspecial('laplacian', 0.2);
laplacian_2 = fspecial('laplacian', 0.5);

laplacian_otf_1 = psf2otf(laplacian_1, [size(blurred_image, 1), size(blurred_image, 2)]);
laplacian_otf_2 = psf2otf(laplacian_2, [size(blurred_image, 1), size(blurred_image, 2)]);

alpha_1 = 0.03;
alpha_2 = 0.05;
alpha_3 = 0.07;

original_image_from_noisy_blurred_11_a1 = real(ifft2(conj(kernel_otf) .* noisy_image_bla
original_image_from_noisy_blurred_11_a2 = real(ifft2(conj(kernel_otf) .* noisy_image_bla
original_image_from_noisy_blurred_11_a3 = real(ifft2(conj(kernel_otf) .* noisy_image_bla
original_image_from_noisy_blurred_12_a1 = real(ifft2(conj(kernel_otf) .* noisy_image_bla
original_image_from_noisy_blurred_12_a2 = real(ifft2(conj(kernel_otf) .* noisy_image_bla
original_image_from_noisy_blurred_12_a3 = real(ifft2(conj(kernel_otf) .* noisy_image_bla
```

```
figure;  
imshow(original_image_from_noisy_blurred_l1_a1, []);  
title("(laplacian alpha = 0.2 | alpha = 0.03)", FontSize=8);
```

(laplacian alpha = 0.2 | alpha = 0.03)



```
imshow(original_image_from_noisy_blurred_l1_a2, []);  
title("(laplacian alpha = 0.2 | alpha = 0.05)", FontSize=8);
```

(laplacian alpha = 0.2 | alpha = 0.05)



```
imshow(original_image_from_noisy_blurred_l1_a3, []);
title("(laplacian alpha = 0.2 | alpha = 0.07)", FontSize=8);
```

(laplacian alpha = 0.2 | alpha = 0.07)



```
imshow(original_image_from_noisy_blurred_12_a1, []);
title("(laplacian alpha = 0.5 | alpha = 0.03)", FontSize=8);
```

(laplacian alpha = 0.5 | alpha = 0.03)



```
imshow(original_image_from_noisy_blurred_12_a2, []);
title("(laplacian alpha = 0.5 | alpha = 0.05)", FontSize=8);
```

(laplacian alpha = 0.5 | alpha = 0.05)



```
imshow(original_image_from_noisy_blurred_12_a3, []);
title("(laplacian alpha = 0.5 | alpha = 0.07)", FontSize=8);
```

(laplacian alpha = 0.5 | alpha = 0.07)

