1) **Original:**

original image

2) **Thresholding:**

a. Threshold Value = 32

b.

threshold

c. All the pixels with intensity values above the used threshold were assigned intensity value of 255 (white) and all those less than the threshold were reduced to 0 (black). Image was converted from a grayscale image to a binary (black and white) image.

3) **Contrast stretching:**

contrast

   b. Range being stretched: [7, 96],

c. Contrast stretching changes the range of intensities to a desired range. On performing contrast stretching, different objects and details in the image are better detectable.

4) **Gamma correction:**

gamma

 c. gamma value = 0.45,

d. gamma < 1, so the lower intensities are enhanced, for example, the reflection in the bottle is enhanced and more detailed than the original image

5) **Histogram equalization:**

histogram stretch

b. On histogram equalization, the histogram of the image is 'flattened' so that all intensities are uniformly distributed. Compared to previous methods, one range is not compressed compared to other and contrast is enhanced in a more sophisticated manner.

CODE:

```matlab
clear
close all


%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%% load the image file and display %%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% read in the image
im = imread('Image.bmp', 'bmp');
im = double(im);

[Ny,Nx] = size(im);

% display the image
figure(1);
imshow(uint8(im));
title('original image');


%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%% thresholding %%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% set the threshold
threshold = 32;

im_threshold = zeros(Ny, Nx);

for i = 1:Nx,
    for j = 1:Ny,
        if im(j,i) > threshold
            im_threshold(j,i) = 255;
        else
            im_threshold(j,i) = 0;
        end
    end
end

figure(2);
imshow(uint8(im_threshold));
title('threshold');
```

```matlab
%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%% contrast %%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

% create a histogram of the image
histo = zeros(256,1);

for i = 1:Nx,
    for j = 1:Ny,
        histo(im(j,i)+1) = histo(im(j,i)+1) + 1;
    end
end

% create the CDF from the PDF (i.e. the histogram)
CDF = zeros(256,1);
CDF(1) = histo(1);

for i = 2:256,
    CDF(i) = CDF(i-1) + histo(i);
end

CDF = CDF/Nx/Ny;

% find the lower limit
for i=1:256,
    if CDF(i) > 0.05
        lower = i;
        break;
    end
end

% find the upper limit
for i=1:256,
    if CDF(i) > 0.95
        upper = i;
        break;
    end
end

gain = 255/(upper - lower);

% apply the contrast
im_contrast = gain*(im - lower);

% dispay the image
figure(3);
imshow(uint8(im_contrast));
title('contrast');
```

```matlab
%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%% apply gamma %%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
gamma = 0.45;

im_gamma = im/255;
im_gamma = im_gamma.^gamma;
im_gamma = im_gamma*255;

figure(5);
imshow(uint8(im_gamma));
title('gamma');
%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%% Histogram equalization%%%%%%%%%%%%%%%%%
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

CDF = 255*CDF;

im_HE = zeros(Ny, Nx);

for i = 1:Nx,
    for j = 1:Ny,
        im_HE(j,i) = CDF(im(j,i) + 1);
    end
end

figure(6);
imshow(uint8(im_HE));
title('histogram stretch');
```