1.

<table>
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<th>7</th>
<th>8</th>
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<tbody>
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<td>7</td>
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<td>8</td>
<td>2</td>
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<td>0</td>
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</tr>
<tr>
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<td>0.0323</td>
<td>0.0968</td>
<td>0.2258</td>
<td>0.2903</td>
<td>0.2581</td>
<td>0.0645</td>
<td>0.0323</td>
<td>0.0000</td>
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<tr>
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<td>0.1290</td>
<td>0.3548</td>
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<td>0.9032</td>
<td>0.9677</td>
<td>1.0000</td>
<td>1.0000</td>
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<td>1.0000</td>
</tr>
<tr>
<td>( \text{cdf} \cdot \text{max(n)} )</td>
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<td>1.2903</td>
<td>3.5484</td>
<td>6.4516</td>
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<td>9.6774</td>
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</tr>
<tr>
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<td>6</td>
<td>9</td>
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<td>10</td>
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<td>0</td>
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<td>0</td>
<td>8</td>
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</tbody>
</table>

Figure 1: Look Up Table for problem 1.

Figure 2: Input and output histograms for problem 1.
2. Pseudo-Code for histogram equalization:
   Load Image
   Compute the histogram of the image.
   Convert the histogram to a Probability Density Function (PDF).
   Convert the PDF to a Cumulative Density Function (CDF).
   Multiply the CDF by the number of output bins – 1 and round/truncate to make a Look Up Table (LUT).
   Apply the LUT to the image to make the histogram equalized image.

3. Figure 3: (a) original image [hw3-1.tif] and (b) histogram equalized image.

Figure 4: Input and output histogram of hw3-1.tif.
Figure 5: LUT for histogram equalizing hw3-1.tif.

Figure 6: (a) original image [hw3-2.tif] and (b) histogram equalized image.
Figure 7: Input and output histogram of hw3-2.tif.

Figure 8: LUT for histogram equalizing hw3-2.tif.
Figure 9: (a) original image [hw3-3.tif] and (b) histogram equalized image.

Figure 10: Input and output histogram of hw3-3.tif.
Figure 11: LUT for histogram equalizing hw3-3.tif.

(a) (b)

Figure 12: (a) original image [lena.tif] and (b) histogram equalized image.
Figure 13: Input and output histogram of lena.tif.

Figure 14: LUT for histogram equalizing lena.tif.

4. Matlab code to compute a 2-D histogram:

```matlab
function [ output ] = hist2d( input )

% this function computes the 2d histogram of input.
% input is an array of size m x n x 2
% input can only have integer values between 0 and 255

s = size( input );
if numel( s ) ~= 3
    error( 'input is wrong size. Expected dimensions m x n x 2' )
end
if s( 3 ) ~= 2
    error( 'input is wrong size. Expected dimensions m x n x 2' )
end
```
out = zeros( 256, 256 );

for i = 1:s( 1 )
    for j = 1:s( 2 )
        x = input( j, i, 1 );
        y = input( j, i, 2 );
        out( y + 1, x + 1 ) = out( y + 1, x + 1 ) + 1;
    end
end

output = out;

end

5. To help with the visualization the log of the histograms are computed.

\[
lh[x, y] \equiv \begin{cases} 
0 & h[x, y] = 0 \\
\log_{10}[h[x, y]] & h[x, y] > 0
\end{cases}
\]  \hspace{1cm} (1)

where \( lh(x, y) \) is the log histogram and \( h[x, y] \) is the 2-D histogram.

Figure 15: (a) 2-D histogram, (b) log(2-D) histogram (c) image of 2-D histogram, (b) image of log(2-D) histogram for images 1 and 2. For the images, black is the 0 and white is the largest value. The upper left in each image represents (0,0).
Figure 16: (a) 2-D histogram, (b) log(2-D) histogram (c) image of 2-D histogram, (b) image of log(2-D) histogram for images 2 and 3. For the images, black is the 0 and white is the largest value. The upper left in each image represents (0,0).
Figure 17: (a) 2-D histogram, (b) log(2-D) histogram (c) image of 2-D histogram, (b) image of log(2-D) histogram for images 1 and 3. For the images, black is the 0 and white is the largest value. The upper left in each image represents (0,0).